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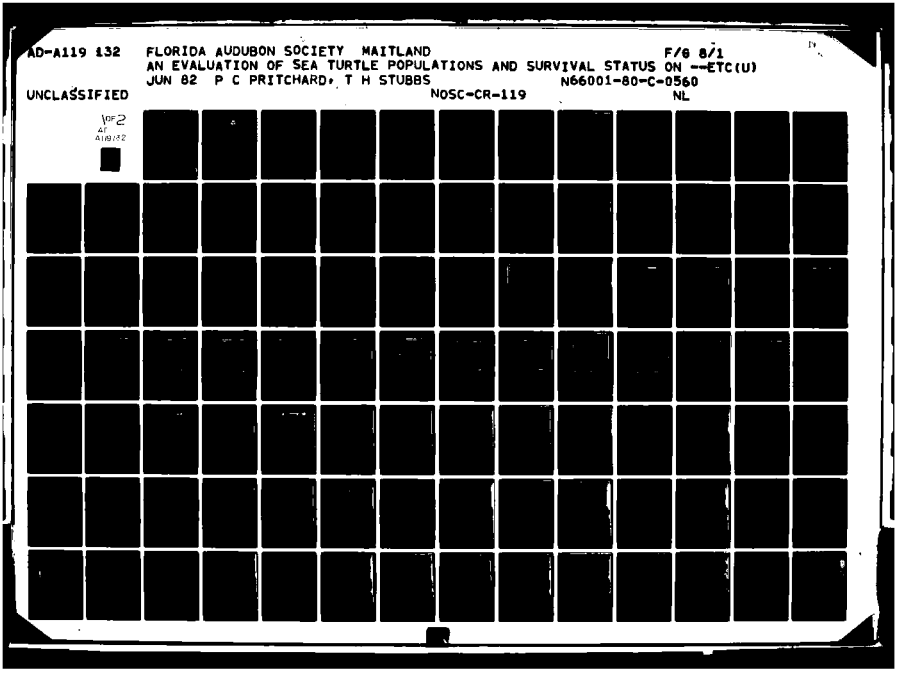

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AN EVALUATION OF SEA TURTLE POPULATIONS AND SURVIVAL STATUS ON VIEQUES ISLAND

P. C. H. Pritchard
T. H. Stubbs
Florida Audubon Society (N66001-80-C-0560)

22 June 1982

Prepared for
Marine Sciences Division

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Work was done by the Florida Audubon Society for NOSC Marine Sciences Division (Code 513).

Released by
S. Yamamoto, Head
Marine Sciences Division

Under authority of
H.O. Porter, Head
Biosciences Department

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Contractor Report 119 (CR 119)	2. GOVT ACCESSION NO. A119132	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AN EVALUATION OF SEA TURTLE POPULATIONS AND SURVIVAL STATUS ON VIEQUES ISLAND		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P.C. H. Pritchard T.H. Stubbs		8. CONTRACT OR GRANT NUMBER(s) N66001-80-C-0560
9. PERFORMING ORGANIZATION NAME AND ADDRESS Florida Audubon Society 1101 Audubon Way Maitland, FL 32751		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Ocean Systems Center San Diego, CA 92152		12. REPORT DATE 22 June 1982 13. NUMBER OF PAGES 108
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Reptiles	Hawksbill
Vieques Island	Loggerhead
Green turtle	Nesting
Turtles	Leatherback

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The nesting of turtles on Vieques Island. The report looks at the effect of human predation on turtle populations. Because few islands are under U.S. jurisdiction where leatherbacks or Hawksbills nest, Vieques Island has special significance.

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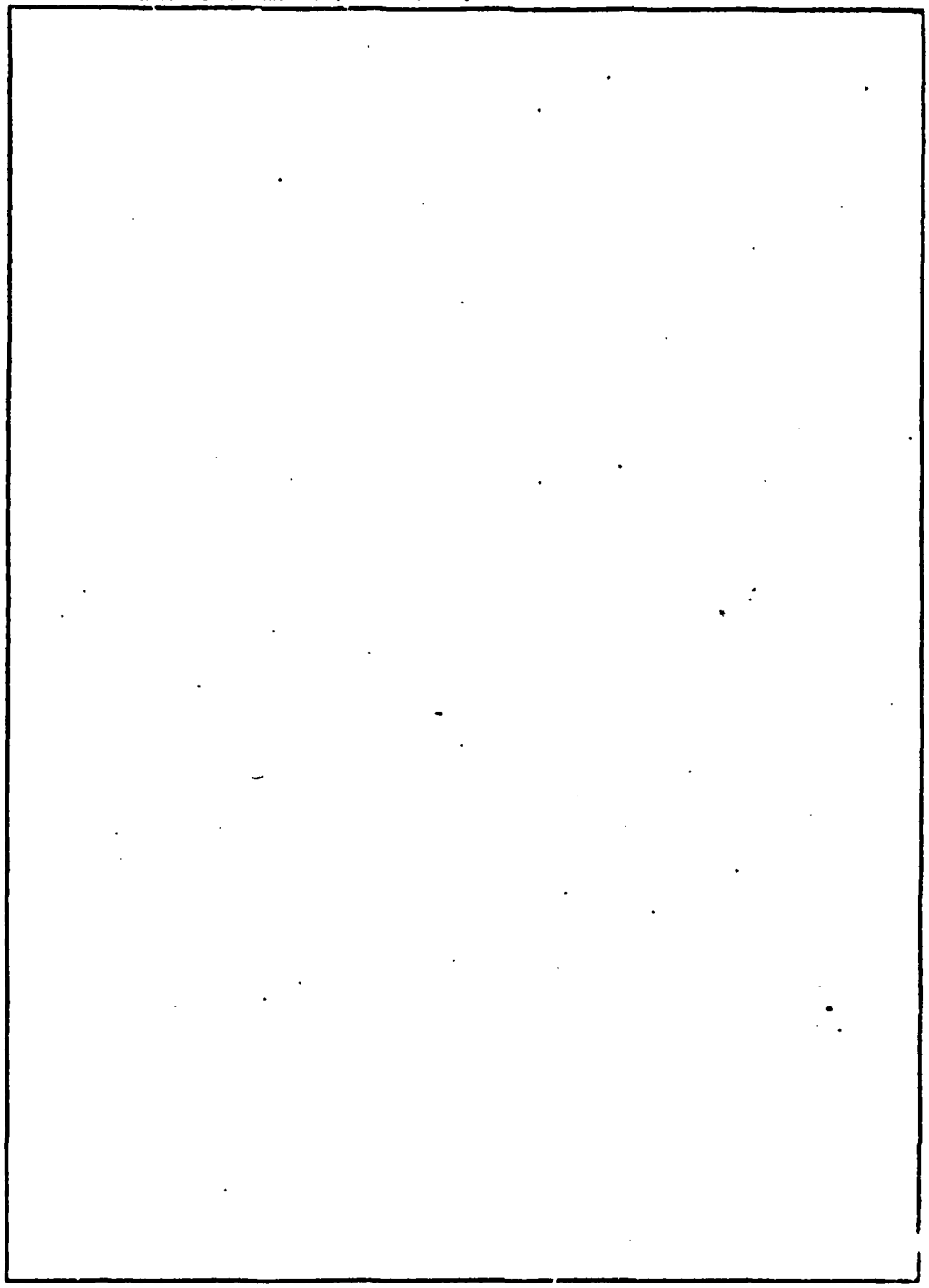

AN EVALUATION OF SEA TURTLE POPULATIONS AND SURVIVAL STATUS ON VIEQUES ISLAND

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Final Report on Contract No. N66001-80-C-0560 (including modification No. P00001)

Department of the Navy
Naval Ocean Systems Center
San Diego
California 92152

1982

CONTENTS

Frontispiece

A fresh hawksbill turtle nest between large boulders on a beach in south-western Vieques.

1. BACKGROUND

Notes in archival publications and information gained by interviewing surviving individuals familiar with the island as long ago as 1910-20 suggest that Vieques once hosted a substantial population of nesting sea turtles. However, details of numbers, species, and nesting areas are sketchy. Recent surveys sponsored by both the U.S. Fish and Wildlife Service (Carr) and the U. S. Navy (Rainey) have revealed rather few sea turtles in Vieques waters or nesting on Vieques beaches, just as we report here. Reasons for the population decline are uncertain, but human predation has probably been a major factor.

Vieques, formerly known as Crab Island, has been inhabited by native Antillean Indians for at least several thousand years, and by Europeans since the 1500's. According to a 1685 report, "besides planting, some of the inhabitants made a living by fishing turtle, which were particularly numerous in the vicinity of Crab Island." (Westergaard, 1917). In 1720, it was reported that "the latter (small boats) were frequently used by white men who with a few Negroes would sail off to Crab Island . . . the best turtle-fishing ground near St Thomas." (Ibid)

The oldest early Vieques resident whom we located was Hector Villafañez, born on Vieques in 1900 and resident there until 1917. Currently he is employed by the United States Park Service in the Caribbean National Forest.

Mr. Villafañez recalled that near Lujan turtles came in "by the hundreds" around 1919-1920. "A dozen or so would nest on the Lujan beach during the summertime."Villafañez said that the turtles and their eggs were not eaten at that time; this, if true, is most unusual for humans who live

in conditions where resources are limited. Certainly it was not true either in the early years of the history of Vieques or today. Conceivably, an abundance of cattle at the time made the eating of turtles unnecessary, and the widespread Latin American (indeed, pantropical) belief in the aphrodisiac qualities of turtle eggs had not yet reached Vieques.

In any event, Villafañez remembers the major threat to sea turtle nests came from the children of Vieques, who dug up the soft eggs to throw at each other in sport. He said that most of the nests were destroyed in the search for projectiles, but that a few must have survived because hatchlings were sometimes seen making their way to the sea.

Today it is widely known that few turtles nest on Vieques beaches or remain in Vieques waters. Juan Castro, 35, has lived on Vieques most of his life. He spends much of his time diving, but says that he sees few turtles. He does believe that there is less poaching now than previously "because the fishermen don't use the large nets as much; they favor the ones pulled behind the boats.Of course, they'll still kill turtles when they come across them."

He adds that "the young people don't want to take the effort to go out and catch turtles. So most of the poaching is done by older people."

Another informant who owns the only diving shop on Vieques,and who spends a great deal of his time underwater in the vicinity of Vieques, sees turtles around the reefs, "sometimes hiding in caves or under ledges . . . but not many."

He believes that the hurricane of 1979 made the island even less attractive for nesting sea turtles. "The hurricane really damaged the reefs, and it also wiped out a lot of the turtle grass beds. All along from Punta Vaca to Punta Negra, there used to be lots of it; now you

just see tips sticking up, because the hurricane covered everything th sand."

This informant believes that poaching of both turtle eggs and meat is extensive. The products are either eaten locally or carried to Puerto Rico for surreptitious sale to restaurants. It is said that restaurants throughout the island sell turtle meat to select customers who are known or trusted by the owner. Belief in the aphrodisiac qualities of turtle eggs has also now reached Vieques. Also, "the turtle penis is considered a powerful aphrodisiac. They get ten dollars an inch for one. They'll eat it (as is) or put it in a bottle of rum, or dry it and make a powder that they put on their beans."

Full-time and part-time fishermen interviewed echoed the same analysis - that there are sea turtles in the waters around Vieques and some nest on its beaches, but there are not many and, within the memory of any but the older residents, there never have been.

In a fishery survey of Puerto Rico reported by Rainey (Wilcox, 1902) sea turtles were listed as not abundant anywhere, but most common around the eastern end, and the islands of Vieques and Culebra. Today Culebra has more nesting Hawksbills than does Vieques, though the few available records suggest that it used to be the reverse. The present relative abundance may stem from inaccessibility of some of the Culebra nesting beaches and the much greater current human population of Vieques (ca. 9,000 vs. ca. 15,000 on Culebra) - though the number of individuals hunting turtles is a more important factor than the total human population. There could be other factors, but we do not know what they might be. Both islands have a long history of use for bombing practice so this factor should cancel out.

In summary Vieques today has rather few nesting turtles but once

probably had more, though the island was never a major nesting site for any species. Nevertheless, there are very few areas under U.S. jurisdiction where either leatherbacks or Hawksbills nest, and this gives Vieques special importance - especially since sea turtle populations have been drastically reduced throughout the region.

2. SPECIES PRESENT

The leatherback turtle *(Dermochelys coriacea)* nests in small numbers on Vieques but there is no evidence of the species being resident in Vieques waters.

The hawksbill turtle *(Eretmochelys imbricata)* nests in low density on Vieques and the species may be found in Vieques waters year-round.

The green turtle *(Chelonia mydas)* nests very rarely on Vieques but immature greens are found in small numbers on turtle grass pastures around the island.

The loggerhead *(Caretta caretta)* is extremely rare in Vieques waters. Only one individual was seen and identified with certainty during the 1980-81 survey.

Neither species of *Lepidochelys* has ever been released from Vieques, though one individual of *L. olivacea* is known from Puerto Rico. (Caldwell and Erdman 1969)

3. STUDY PERSONNEL

Peter C.H. Pritchard, M.A., Ph.D.

Dr. Pritchard is Vice President for Science and Research of the Florida Audubon Society, Maitland, Florida. He has been a specialist in marine turtles since 1965. His research programs on turtles have taken him to many parts of the world, including Mexico, Venezuela, Honduras, Guyana, Surinam, French Guiana, the Galapagos Islands, Micronesia, New Caledonia, and Papua New Guinea. He is the author of "Living Turtles of the World," "Encyclopedia of Turtles," and about 80 scientific and popular papers and articles on the subject. He has also worked as a consultant for the US Fish and Wildlife Service, National Marine Fisheries Service, World Wildlife Fund, and other governmental and non-governmental agencies.

During the course of the present study, Dr. Pritchard was responsible for administrative and policy aspects, and he made five field visits to Vieques during the study-year.

He is Co-Leader of the South-East Region Sea Turtle Recovery Team, and a member since 1969 of the IUCN Marine Turtle Specialist Group.

Thomas H. Stubbs, M.A.

Mr. Stubbs has an extensive background in field biology, especially marine turtle studies, as well as cinematography. He has worked with marine turtles in Mexico, Surinam, and French Guiana, and is the co-author of two textbooks on human ecology; he also produced the acclaimed motion picture "Silent Sirens: Manatees in Peril," a documentary

on the Florida manatee.

Mr. Stubbs was resident on Vieques throughout the study-year, and had prime responsibility for field aspects of the study.

4. PREVIOUS STUDIES

Tom Carr, in a brief reconnaissance of Vieques sponsored by the Puerto Rico Department of Natural Resources found, as we did, that the current population of nesting sea turtles on Vieques is almost entirely Leatherbacks and Hawksbills. He also heard that in years past Green Turtles and even Loggerheads nested on Vieques beaches, although we found extremely few nests of "medium-sized turtles" (i.e. Greens or Loggerheads). Immature Green Turtles are still fairly abundant in Vieques waters, but apparently in smaller numbers than reported by Carr. Possibly, one of the subsequent hurricanes reduced populations - we know they damaged the turtle grass beds.

Carr also observed that "adjacent to the maneuver and impact areas military activities in the area have caused disturbance and destruction of reef habitat. Fragmentation of hard coral there is obvious and extensive. What appears to be a further serious disruption at this locality is extensive collapse of old coral that serves as support for new reef growth." The assumption that military activities are responsible for the conditions observed may well be in error (see section 6.3.2.). It is not consistent with the data on ordnance shortfalls to assume that extensive reef destruction is due to bombing.

Although Carr's observation that respect for the conservation laws is meager concurs with our findings, awareness of those laws is surely more widespread now than it was during the time of his brief study; the inclusion of all species of sea turtles under the protection of the Endangered Species Act in 1978 has caused much publicity for sea turtle protection.

A more extensive but still brief study was conducted for the U.S.

Navy by William Rainey in 1978. Rainey was on Vieques from the 16th of May until June 10th, then again on August 29-30 and September 4-7.

Rainey's findings corroborate our own in many respects. During his first and longest period on the island, Rainey observed 15 turtles on a total of eight aerial surveys. In August of 1981 we recorded 18 turtles on nine flights. In October, however, we saw 80 turtles on 15 flights, with a striking shift in the distribution around the island (see discussion of results).

Rainey found that nesting was the most intensive on a few beaches on the eastern end of the island, as did we. He still found rather few nests and concluded, as did we, that if multiple nestings are taken into consideration, then the total number of turtles nesting on Vieques is small indeed.

Rainey's study was fairly brief but was well-designed and we are encouraged that its conclusions were completely compatible with those of our year-long study.

However, Rainey was not on the island during the post-nesting months, when we witnessed a striking increase in turtles in the water around Vieques, and it is thus highly desirable that studies continue at least during the nesting and immediate post-nesting months in future seasons.

5. METHODS

5.1 Beach Surveys:

During the initial phase of the Vieques turtle study much of the effort was directed toward a consistent, thorough coverage of beaches, on all parts of the island but especially on Navy lands, to determine if, when, and where nesting takes place. Because the study began in October, we did not anticipate that much if any nesting would take place until spring; nonetheless, it was considered that negative information would be of value in that it would help the Navy in planning the timing of its heavy activities, and it would provide base-line data for any future studies, as all past overviews of Vieques sea turtle nesting had been of short duration. The surveys demonstrated that nesting is probably very infrequent from October until the end of March; it is possible that there may be years in which the nesting patterns are significantly different, but in the absence of evidence we assume this is not the case.

For reasons outside our control, aerial surveys did not start until August 1981; from October 1980 until then we were restricted to land (and ocean) reconnaisance.

There were no indications of turtle nesting from October through March. Although one Hawksbill emergence was recorded in December; this apparently did not result in a nest. Despite the absence of positive feedback, we deemed it important to delimit the nesting season by observation rather than assumption, and considerable effort was made to visit beaches all year round.

When nesting began in April, it continued steadily, although never

abundantly, into September. In October nesting activity diminished sharply, as we anticipated. (See maps).

With the exception of the Hawksbills, which are more able to take advantage of beaches with difficult or rocky approaches, our findings indicate that relatively few of the beaches of Vieques are used for nesting by sea turtles. In many cases it was not clear why some beaches were avoided. Doubtless a complex of subtle physical factors including currents, offshore topography, and beach profile, control use of a given beach by sea turtles. Rainey's findings (1978) are similar to ours.

5.2 Aerial Surveys:

Aerial surveys were started in August. They yielded excellent information with a very modest time commitment. First, it was possible to cover every beach on the island in a very brief time, turtle tracks were so obvious, particularly during the early morning when the angle of light made them especially easy to see, that there was little possibility of missing one. Second, it was possible for us to count turtles in the marine environment, and in some cases to identify the species positively. When flying at altitudes varying from 500 to 200 feet it is not always easy to be certain of species, and sometimes one cannot be sure if the object seen was a sea turtle, a piece of debris, or some non-chelonian organism, particularly if the water is at all choppy. Even so, this was the most effective altitude to observe turtles in offshore waters.

Because there was an immediate and pressing need for as much data as possible regarding the distribution and numbers of sea turtles in the vicinity of the bombing range, no attempt was made in our case to evenly

cover the island. But in the light of the manifold variables that may affect the numbers of turtles seen from an aircraft, equal time spent over both productive and non-productive sections of the coast would still not yield truly qualitative data or relative population densities. In fact, given the potential for factors affecting sightings from one day to another, it is remarkable that the numbers seen were as constant as they were. As the probability of spotting a turtle has to related to biological, environmental, and methodological factors, not to mention the number of observers in the aircraft, the concentration of observers, and sheer chance, aerial survey findings are only useful in so far as they yield positive data. Many factors other than their actual absence can result in turtles not being seen.

A drawback to aerial surveying is that the noise, and sometimes the shadow, from the aircraft will cause the turtle to dive. Also, it has to be assumed that the figures obtained, although important, represent only an undetermined fraction of the true population. Young turtles, in particular Hawksbills, are probably more likely to be submerged and they are also not as easy to see, if only because of their smaller size. We believe that the Hawksbill population in Vieques waters is much larger than our surveys suggest because, although we recorded very few sightings of juveniles, in underwater surveys young Hawksbills always outnumber mature ones substantially. But in spite of the disadvantages, there is no more effective means for making relative population estimates in a case like this except for a netting and tagging program, which was outside the parameters of this study.

5.3 Marine Coverage:

In an effort to survey marine turtles from the water, a boat was ob-

tained in March for the purpose of observing turtles with: a reasonably short distance from shore. However, this approach was not uccessful. A boat would have been essential if we had been netting and tagging or if the investigation had involved scuba searches, which it did not. Otherwise, there is little possibility of observing turtles from a boat in anything approaching the statistical significance of aerial surveying because the noise of the motor causes them to dive, often before the surveyor is within sight, and because the area of ocean in which turtles would be visible is so much less from a boat than from the air.

5.4 Comparative value of different survey techniques:

To obtain estimates of population densities and nesting activities, aerial surveys followed by ground truthing yield the most comprehensive information. A netting and tagging program offers some advantages, but also some drawbacks; within the scope of a single year the tagging may not yield useful data. And netting, whereas it would surely take in turtles that might not be seen from the air, might be inadvertently selective in other respects.

Generally the time-honored method of covering beaches on foot may be considered desirable only as a substantiation of aerial observations or when there is sufficient nesting to ensure that nesting turtles will be encountered. On Vieques the nesting was so sparse that even on the best beaches the probability of finding turtles ashore was slight.

5.5 Interviews:

Interviewing local people for information on sea turtle abundance

nesting locations, exploitation and other aspects is a potentially valuable supplement to direct gathering. At best, it can allow the researcher to gain the benefit of many lifetimes of observations; it may also be fraught with intentional misinformation or well-intentioned but erroneous ideas. In conversations with Viequenses we found that often even the fishermen had little to say about sea turtles except that they were indeed present, although never in great numbers, and that they may often be found around the reefs.

A complication in the case of Vieques that made relying on secondary sources even less tenable in many cases was the antagonism directed toward the Navy, especially by a segment of the island's fishermen. Additionally, there was a widespread and largely unshakable conviction on the part of many Viequenses that the field investigator was a covert agent for the CIA, the Navy Secret Intelligence or the FBI. The rumor was a very real impediment to unobstructed communication with the islanders.

In any event, the data desired as a focus of this study was best obtained by direct field observation. Interviews, although they provided some insight into the severity of poaching, were of very limited value in yielding other kinds of information.

6.1. BEACHES

Most of the beaches on Vieques may be characterized as gently to strongly curving, of moderate width, and terminating at either end in rocky cliffs that may extend only a few feet or much farther before meeting another beach. The sand and compaction are relatively uniform; there are differences, but none of a degree to affect turtle nesting (see section 6.13). Hendrickson Balasingam (1966) and Hirth (1980) discuss the substrate types acceptable to nesting turtles.

Marine access to the beaches varies from quite open (e.g. Turtle Beach and Yellow Beach), to those almost entirely blocked by high reefs or rock outcroppings, such as a few of those along the southwest coast. Most, however, are at least partially accessible to turtles during some stages of the tide.

Terrain behind the beaches varies. At some points a rocky cliff may rise abruptly from the beach; elsewhere the incline is extremely gradual. During the year of this study there was not much change in the character of most of the beaches. Turtle Beach, Yellow Beach ,and Purple Beach underwent the greatest fluctuations.

The vegetation on and bordering Vieques beaches consists of predominant plant species that are found along all the coast in varying degrees of abundance. The beach morning glory *(Ipomoea pes-caprae)*,almost a universal littoral in the Caribbean, is present on most beaches above the intertidal zone. Patches of sand spur grass *(Cenchrum spp.)* are common, usually closer to the beach scrub communities. On many beaches, especially disturbed ones, other plants stand out as well, such as the giant milkweed *(Calotropis procera)*, castor beans *(Ricinus communis)*, nickers *(Caesalpinia divergins)*,

Stachytarpheta jamaicensis, and *Sida rhombifolia*.

Seagrapes *(Coccoloba uvifera)* are an attractive dominant form in the beach scrub, as are the thorny *Prosopis juliflora* and various species of *Acacia*.

Yellow and Turtle Beaches were the most important for sea turtle nesting. They are both near the eastern end of Vieques, but apart from having generally favorable size and topography, they lack obvious features to make them superior to several other Vieques beaches.

6.1.1. BEACH DESCRIPTIONS

Individual descriptions of major named beaches follows, with a subsequent more generalized account of other beaches of the island.

YELLOW BEACH

This is a gently curving beach approximately 920 meters long on the south side of the island, its eastern end lying at the foot of Cerro Matias. Its seaward access is relatively unobstructed. On the eastern end of the beach crumbling low cliffs of weathered granite rise, cut off at the end by a stream outflow. About half-way to its western extreme the cliffs disappear, to be replaced by a sandy bluff on which grows a profusion of the giant milkweed *(Calotropis procera*, see photo 23) abundant on Vieques, the beach morning glory, *(Ipomoea pes-caprae)* and sea grapes *(Coccolobra uvifera)*.

Although some of the morning glory grows on the beach itself, there is presently not enough to obstruct nesting; most of the beach is free of vegetation. There is a reasonable amount of natural and anthropogenic debris, of many varieties - tree trunks, bottles, boots, plastic dolls - but not

enough to affect the ease with which a turtle might make a nest. (See photo 24)

There are scattered accumulations of seaweed, but the matting of it is not consistent; it does not appear to be dense enough even at its thickest to interfere with turtle nesting.

Cattle tracks are often abundant at the eastern extreme, but not bad elsewhere. Vehicle tracks are usually present over a small area in the middle of the beach that is easily reached from the unpaved road that carries traffic to the observation post at Cerro Matias. Fortunately this is a limited section of the beach and is not where most of the nesting takes place.

There is a marked shifting of sand during the year on Yellow Beach; the pattern is normal and does not suggest that the beach will experience any major changes in the near future (G.d'Alluiso-Guerreri, pers. comm.). We found almost no difference in the structure of the beach in September 1980 and November 1981 despite significant changes between these dates.

TURTLE BEACH

A relatively broad beach about 350 meters long on the north coast near the eastern tip, Turtle Beach is the most dynamic of Vieques beaches. Because of its fluctuations, some of the turtle nests made there during the 1981 season were destroyed, but these were few. (See photos 19 and 20)

Seaward access is clear; close as it is to the rough waters at the eastern end of Vieques, wave action is strong, causing a steep, but navigable incline to much of the beach.

There is very little debris or seaweed on the beach, as is true of most of the north coast. Its broad, sandy sweep provides good nesting habitat.

Behind the beach, past a bluff, terrain is relatively flat. There is an

abundance of milkweed and scrubby bushes. However, there is almost no vegetation on the beach itself.

Cattle tracks are numerous on Turtle Beach, especially near the line of vegetation where turtle nests are often made. They may well constitute a problem to turtle nests.

PURPLE BEACH

Purple Beach is a slightly curving beach 1200 meters long on the north coast. It is moderately wide, with clear seaward access at all points. Wave action is usually strong, especially toward the western end, which shows more change throughout the year than the eastern half. Occasionally low bluffs are formed, but never for the length of the whole beach, and in any event they are seldom so high as to impede the advance of a sea turtle for more than very short distances. Turtle nesting occurred almost entirely at the western end of the beach, a fact probably related to the direction of the currents that sweep against it.

There is a thick growth of *Ipomoea* along the beach (see photo 10) from its midpoint toward the east; westerly, it recedes. A large stand of coconuts grows along the western half, probably dating from pre-Navy days when people lived over the whole island. Otherwise, sea grapes, milkweeds, and low bushes comprise much of the vegetation.

There is a small brackish lagoon behind the eastern end of the beach. Cattle are abundant in that area, as their tracks attest, but they rarely go closer to the western end. Purple Beach is also frequently used by Vieques "cowboys", who walk their horses and cattle near the vegetation line. The impact of the horses and riders alone, without the cattle, would probably be negligible.

Near the western end another small lagoon drains over the beach, but only during periods of heavy rain. Ordinarily the outflow is blocked by a sandbar.

GARCIA BEACH

A crescent beach on the south coast about 230 meters long, Garcia appears to be a perfect location for sea turtle nesting; but during the 13½ months of our study, no nest was ever made there. This was also the case with a number of other Vieques beaches that gave the appearance of offering ideal sea turtle nesting.

It is a broad sandy beach, especially in the center, with a generous growth of morning glory. There are some large *Ficus* trees next to the beach at its eastern end, and large sea grapes as well. Toward the western extreme vegetation becomes scrubbier, merging into the thick tangle of bushes, *Thrinax* palms, low sea grapes, and other exposure-tolerant plants that grow on the rocky promontories of the south coast.

Somewhat east of its center the beach sweeps up to meet a mangrove lagoon. At times water probably flows from this lagoon to the sea, but during the course of our study this was not observed.

Debris and seaweed tended to be concentrated at the west end of the beach. Although it might have discouraged nesting there, the remainder of the beach was usually clear. Seaward access, with the exception of a small island fronting part of the beach, would have provided no problems for turtles.

RED BEACH

Separated from Garcia Beach by a narrow rocky projection, the 275 meter Red Beach is another that seems to be ideal for nesting, but again is

in our experience, unused by turtles. Somewhat longer and slightly more curving than Garcia, it presents unobstructed access to clear sand reasonably free of vegetation and debris. On the upward extreme of its gentle slope there are morning glory vines, other low vegetation, and a few isolated coconut palms. The terrain behind the eastern half of the beach is almost flat, a plain of acacias and other thorny bushes that merges into mangrove swamps further back. Toward the western end, about a hundred meters back from the beach, a rocky limestone slope rises abruptly. Some large *Ficus* trees precede a densely wooded area.

Significant aggregations of debris or seaweeds are absent from Red Beach. Like most of the south beaches removed from the turbulent eastern waters, it undergoes little change throughout the year.

Red Beach is used for landings by troops of the U.S. Navy and the Marines. Where these take place the impact on the beach is evident, as deep ruts are often left by heavy vehicles. However, the landings usually are affected only in the center of the beach, where there is probably the least likelihood of turtle nesting. These activities are thus almost certainly related to the absence of nesting.

Although on Navy property, this beach is open to civilians and is very popular. However, impact of human uses does not seem substantial enough to represent either a threat to the physiography of the beach or to turtles. The Navy beaches are off-limits at night, so no legitimate visitors would be present when nesting is likely to take place. Illegal visitors (especially turtle poachers) presumably concentrate where turtles or their nests could be found more predictably.

BLUE BEACH

This is an impressively long, (1850 meters) wide beach on the south coast, (see photo 26),east of Red Beach. Somewhat less than the west half of Blue Beach consists of a very wide, flat swath of sand that terminates in a rocky peninsula. At its western extreme there is an outflow from a mangrove lagoon, but it is only open during periods of high rainfall.

Toward its eastern end Blue Beach narrows from about 100 meters wide to, in places, only a few meters. Where it narrows it is bordered by a forest of large sea grapes, mangroves, and some other hardwoods; at its widest the vegetation is largely giant milkweed and morning glory, until at the western end there is again mangrove following the channel that occasionally drains the nearby lagoon.

The beach profile remained almost stable during the study period; the slight changes observed occurred in the vicinity of the outflow.

Again, this seems to be excellent for nesting; but we found none in the course of the year. In some areas the morning glory is thick, but certainly not too thick for at least Hawksbills to nest.

Blue Beach is also a point of major landing manuevers (see photos 27 and 28) by the Navy and Marines. When these occur, they impact the part of the beach where one might expect to find turtles nesting. But as elsewhere, the landings are diurnal, and thus one would not expect a sea turtle to be affected by the activities themselves; nor is there reason to believe a sea turtle would be put off by churned up sand. The manuevers might conceivably damage nests in place on the beach, but surely are not themselves responsible for the failure of turtles to nest on the beach at all.

GREEN BEACH

At the northwest end of Vieques, this is a broad beach terminating on its northern end in a small sandy peninsula; at its southern end it dissipates into a series of narrow, rocky beaches. The uninterrupted part of the beach, including the peninsula, is 550 meters long.

Behind it there is forest of sea grape, mangrove, *Ficus*, tropical almond, coconut palms, acacias, and other vegetation. The southern end of the main beach is bordered by a rather steep bluff, but the central portion has a mild incline.

We found only a single turtle nest on Green Beach during the season, that of a Hawksbill on the west side of the peninsula. Aerial surveys have shown most of the turtles on the western end of the island to be clustered around the southwest coast, so when they do nest - the nesting is almost certain to be Hawksbills - they are more likely to emerge on one of the many small beaches that occur from Playa Grande Sur up to Green Beach.

Green Beach is used heavily by the civilian population and the Navy personnel stationed at NAF, so the human impact is relatively strong and more regular than perhaps any other beach. But it is probably inconsequential in terms of turtle nesting; as with other "ideal" beaches on Vieques where there is little or no turtle nesting, it is improbable that any human activities other than poaching are responsible for the dearth of turtles.

PLAYA GRANDE SUR

This beach is 1950 meters long and begins near the south border of NAF. Playa Grande Sur is difficult or impossible for turtle nesting (except for the most athletic Hawksbills) because of the nearly unbroken rocky shelf that fronts the beach in most sections. Between the beach and the

packed earth road behind there is a tangle of sea grapes, coconut palms, some pineapples left over from the days of agriculture and other low vegetation. On the other side of the road there is a large lagoon encircled with a thick forest of mangroves, *Ficus* and other trees.

In addition to the effective barrier of rock, Playa Grande has a much higher shell content than the eastern beaches. There are some good stretches of sand along the beach, but these are not really accessible, which alone may account for the lack of a single sea turtle nest during 1980-81. (See photo 32)

Cattle are present on Playa Grande, but again, they function more as destroyers of nests than as deterents to nesting. However, boisterous cattle activity on a beach at night, if it occurs, would probably discourage turtles from coming ashore.

Aside from the fringing border of rock, there are numerous rock outcroppings in the waters from Playa Grande to the west. These do not constitute an impediment to Hawksbills, but they may prevent nesting by other species.

THE SOUTHWEST COAST

West of Playa Grande, the south coast of Vieques can best be described as a series of small crescent beaches separated by rocky outcrops of varying width and bordered landward by rocky cliffs of highly variable angle of incline, but which tend to be more broken and less steep the farther one goes west. There are numerous quebradas, or gullies caused by drainage erosion (See photo 35).

The rock is principally weathered granite with extrusions of other minerals. At this point (see photo 34) much of it is rather soft and crumbly.

The first beach to the west of Playa Grande is isolated at both ends by rocky cliffs. The beach is sandy, with little debris or vegetation, and its seaward access is clear. It is a favorite among the southwest coast for the cattle, perhaps because the slopes to the beach itself are gentle; there is inevitably a high density of cattle-foot-prints and manure on the beach. (See photo 39)

About a kilometer beyond this beach begins a long, sandy beach, much of which is fairly accessible seaward. At its eastern extreme there is a deep quebrada. An old grove of coconuts and large sea grape trees are the dominant vegetation at this end. (See photo 33)

As one follows the beach, there are seaward borders of rock, but just as much, probably more of the beach is clear. To the west it begins to narrow, curving into a crescent that is fringed by a crumbling cliff. It ends (see photo 37) in a rocky finger that begins the pattern for the next several miles.

The nature of most of these beaches along the southwest coast is fairly uniform. They tend to be slightly curving, of moderate width varying from an extreme of less than a meter wide at a few points to about 10 meters at the widest. All of them have some obstruction to seaward access in the form of rock shelfs that may present a complete barrier or a partially submerged one that Hawksbills might navigate without too much difficulty (see photo 38). Few of the beaches are completely blocked.

As one continues west from Playa Grande, the land behind the beaches gradually becomes more sloping; this corresponds to increased distance from Monte Pirata, the highest mountain on Vieques. There is an increase in the percentage of more xenic-adapted vegetation, such as *Plumeria* (see photo 41).

As the terrain leading away from the beach becomes less steep, there is

an increase in large boulders on the beach itself. These are generally concentrated at the ends of the beaches: they vary from less than a meter in diameter to some that are as much as seven meters or more in height and diameter. Generally they are unlikely to constitute obstacles to nesting turtles, but their shadows do reduce the insolation on much of the beach otherwise suitable for (see photo 44) nesting.

To the north, the beach areas become considerably smaller and are strewn with small rocks, pieces of coral and other debris that might discourage nesting. Adjacent vegetation also changes, largely because of a dramatic change in the terrain behind the shore, which flattens out into a large lagoon fringed with mangroves. Subsequently mangroves are found in some abundance along the shore, along with tropical almonds in greater numbers, and more coconut palms. Acacias are also present; these are dominant in the interior of Vieques, but otherwise uncommon on most of the southwest coast.

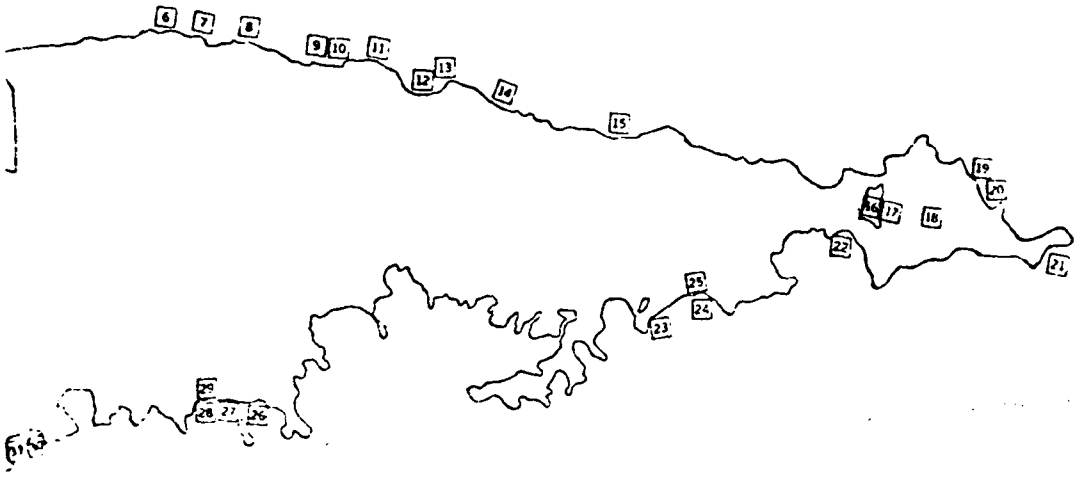
The marine topography changes noticeably on the west end of the island. There is less rock outcropping that might discourage turtles from emerging, although the beaches themselves are less suitable.

The only wide, sandy beach on the west end of the island is Green Beach. Beyond Green Beach, following the northwest coast eastwards, there are some beaches, but most are narrow and backed by hypersaline lagoons; salt water intrusion could easily occur here, with fatal results for turtle nests.

6. 1.2.

BEACH PHOTOGRAPHS

PHOTOGRAPHS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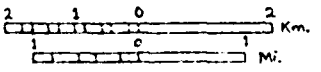
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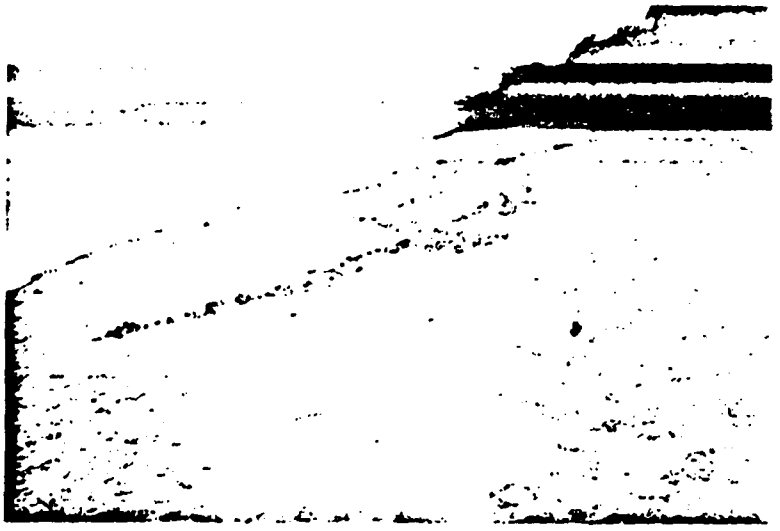


Photo 1 : Green Beach, at the northwestern end of Vieques. Despite its suitable appearance, only a single Hawksbill nested there during the 1981 season.

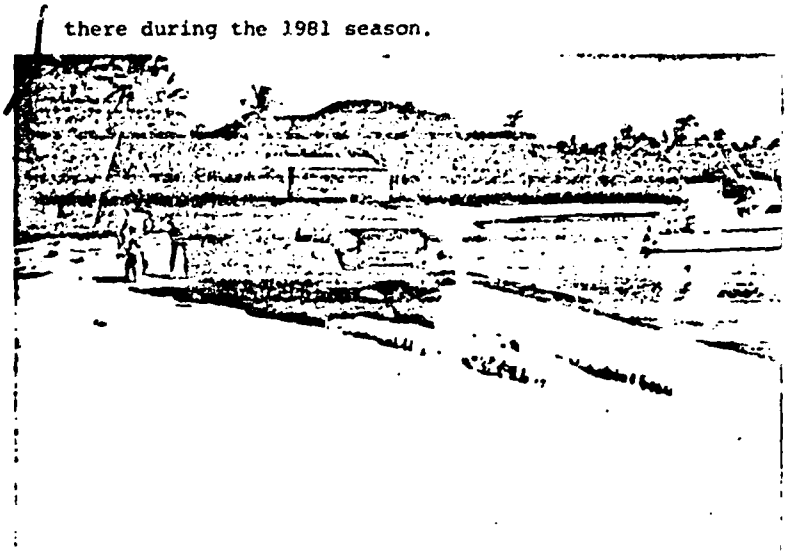


Photo 2 : Vehicle traffic - civilian and military - should be prohibited on Green Beach.

Photo 3 : Severe erosion at the north end of Green Beach, between the main part of the beach and the "peninsula" of sand at its northern extremity.

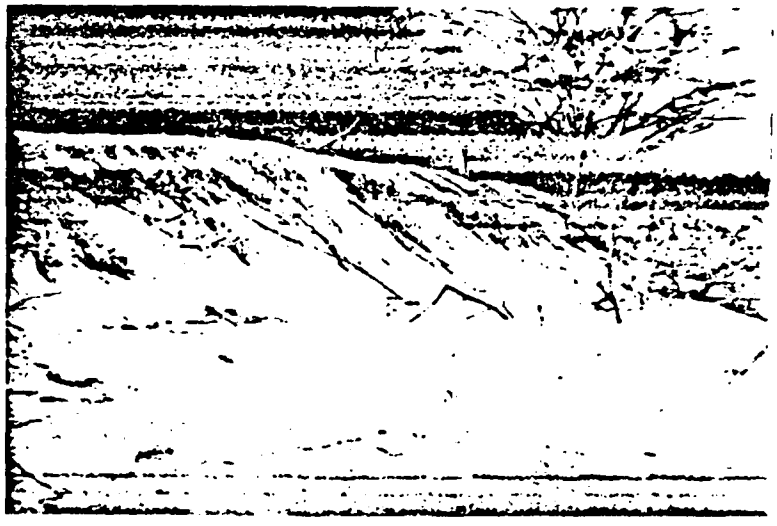


Photo 4 : Erosion at Green Beach is creating bluffs that might discourage nesting turtles.

Photo 5 : The northern extremity of Green Beach.

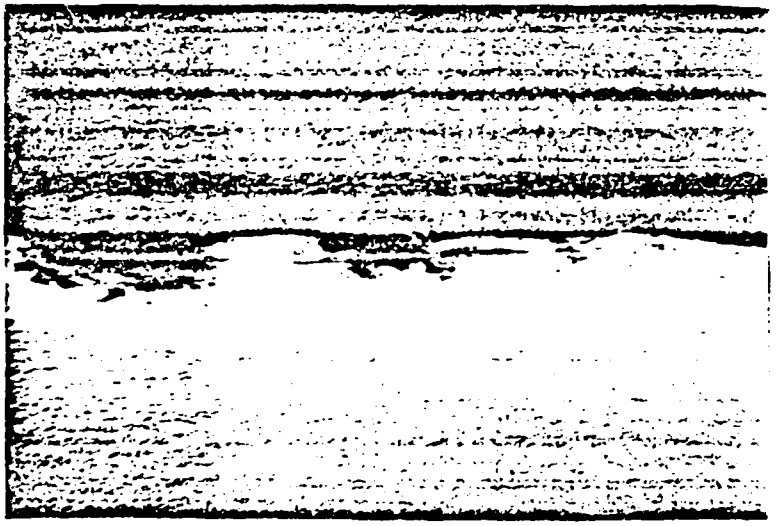


Photo 6 : The northeast coast of Vieques is characterized by a series of small beaches.

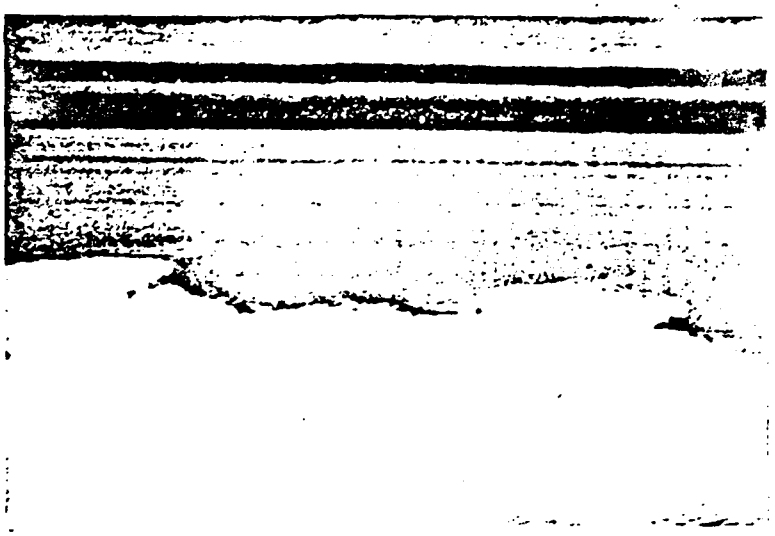


Photo 7 : Drainage channels on Vieques often culminate on beaches, as illustrated here.

Photo 8: Northeast coast.

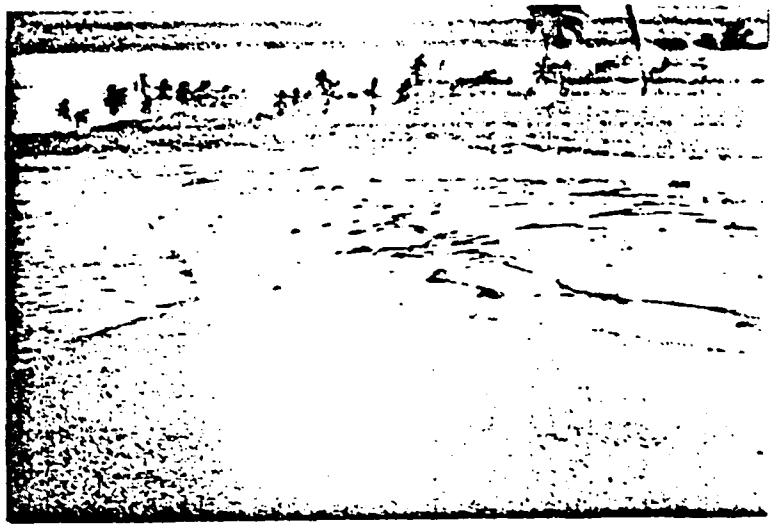


Photo 9 : Purple Beach, looking west. Although a long and wide beach, it is little used for nesting.

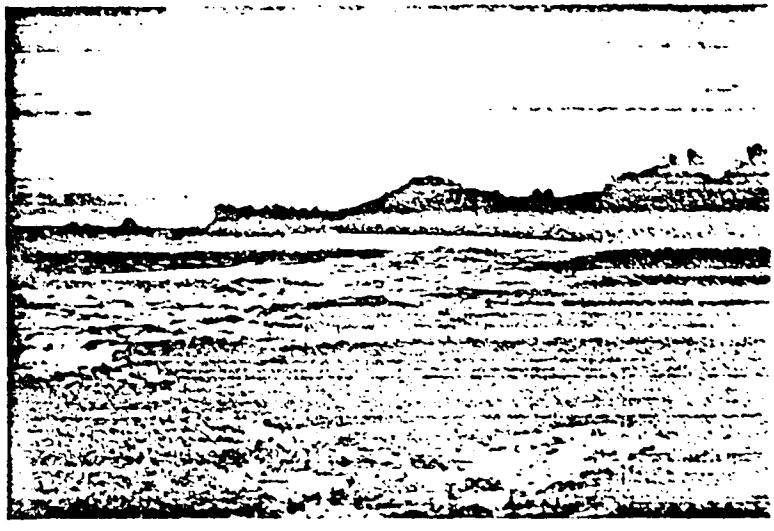


Photo 10 : Morning Glory *(Ipomea pes-caprae)* is abundant on Purple Beach.

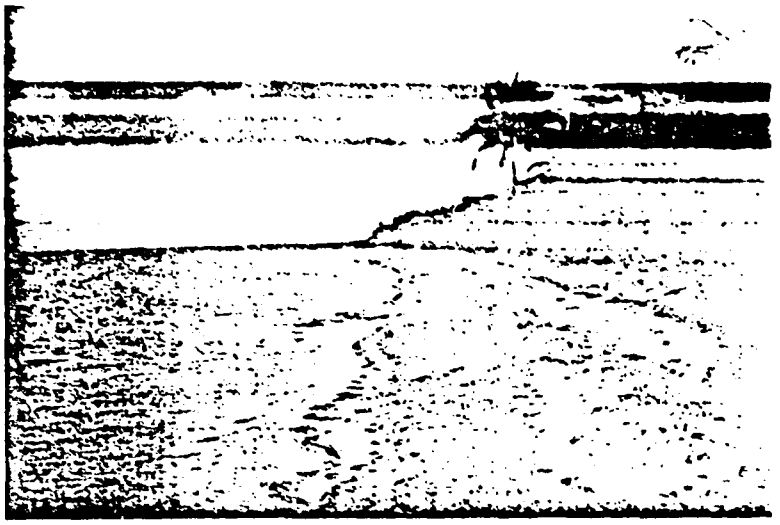


Photo 11 : Directly east of Purple Beach the north coast beaches are relatively narrow for several miles.

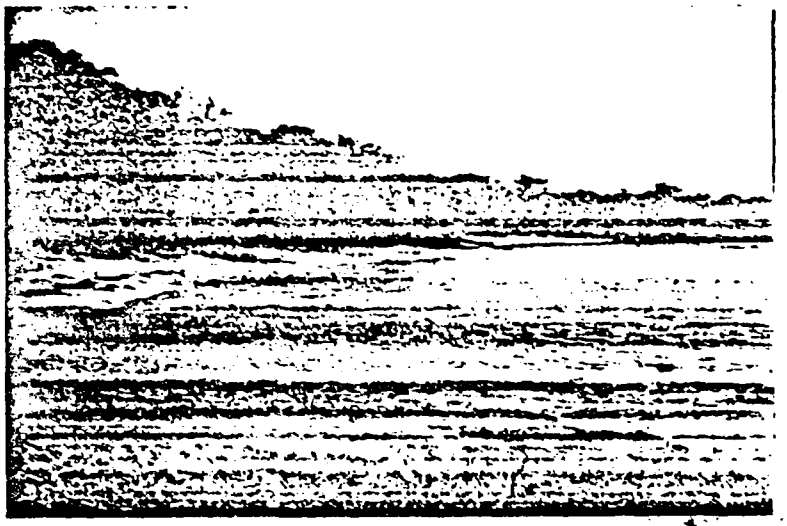


Photo 12 : A beach on the northwest coast. The combined factors of a rocky access and narrow beach would discourage nesting by any but Hawksbills.

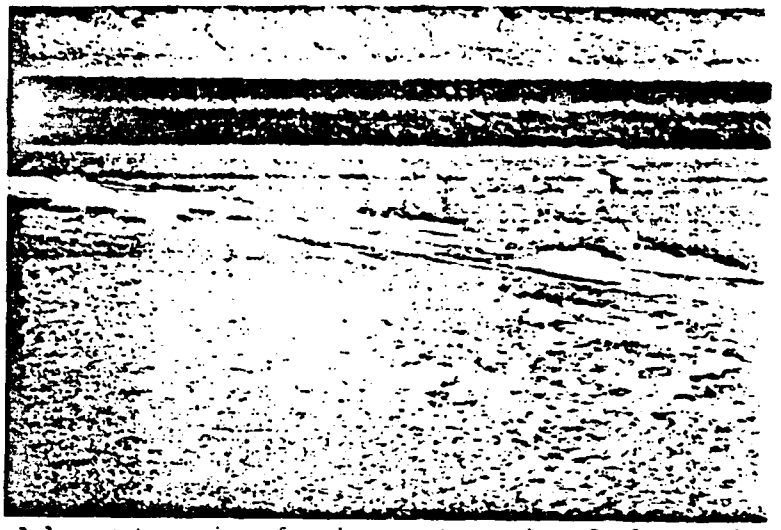


Photo 13 : A long outcropping of rock presents an obstacle for nesting turtles on this north coast beach.

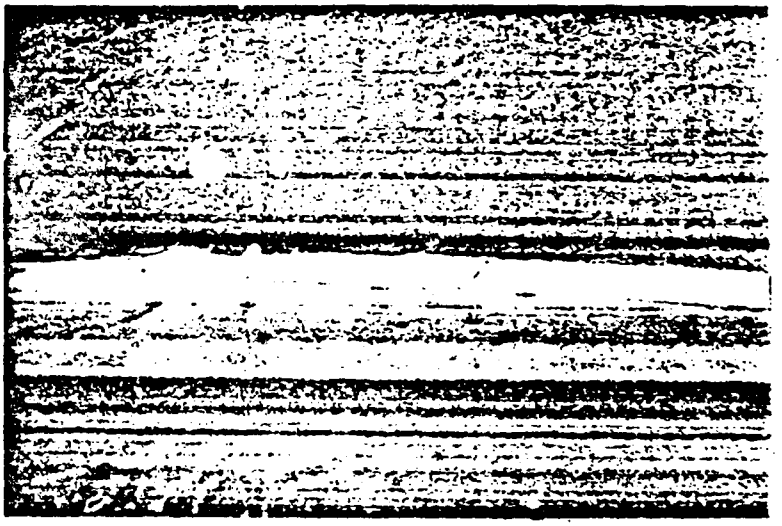


Photo 14 : Northeast coast.

Photo 15 : Puerto Diablo on the north coast. Hawksbills were occasionally seen in the lagoon.

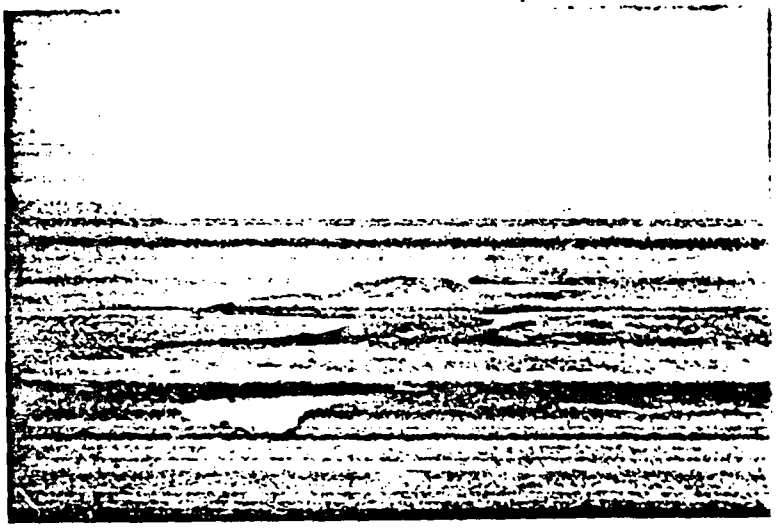


Photo 16 : The bombing range of the Atlantic Fleet Weapons Training Fleet (AFWTF). Ordnance shortfall from this area does not appear to represent a significant threat to sea turtles.

Photo 17 : Atlantic Fleet Weapons Training Fleet.

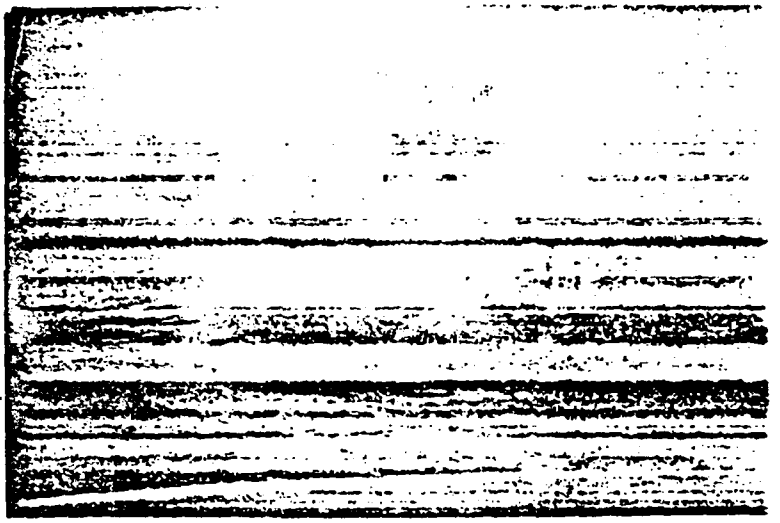


Photo 18 : Ordnance detonation on the AFWTF range is visually impressive, but probably has little effect on sea turtle nesting.

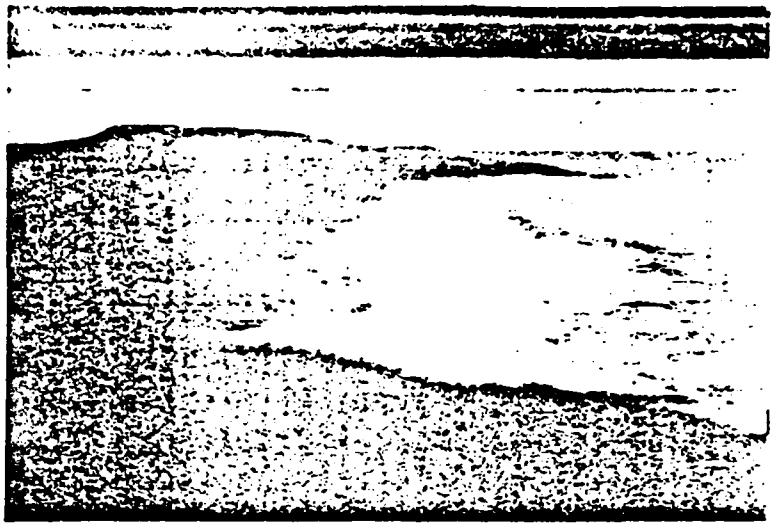


Photo 19 : Turtle Beach - northeast Vieques. This high-energy beach is one of the two major turtle nesting beaches on Vieques.

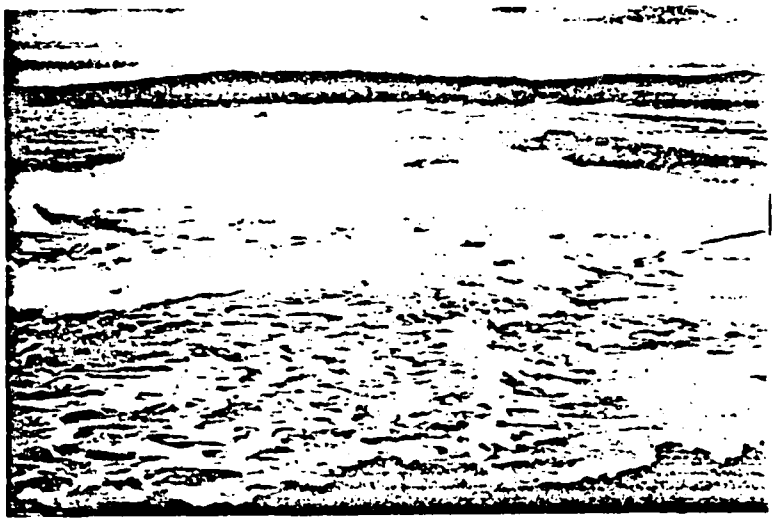


Photo 20 : Turtle Beach undergoes some alteration during the course of a year, but the changes are minimal.

Photo 21 : Rocky coastline near the southeastern extreme of Vieques.

Photo 22 : A beach on the south shore of AFWTF, used as a roadway, should be protected from vehicular traffic.

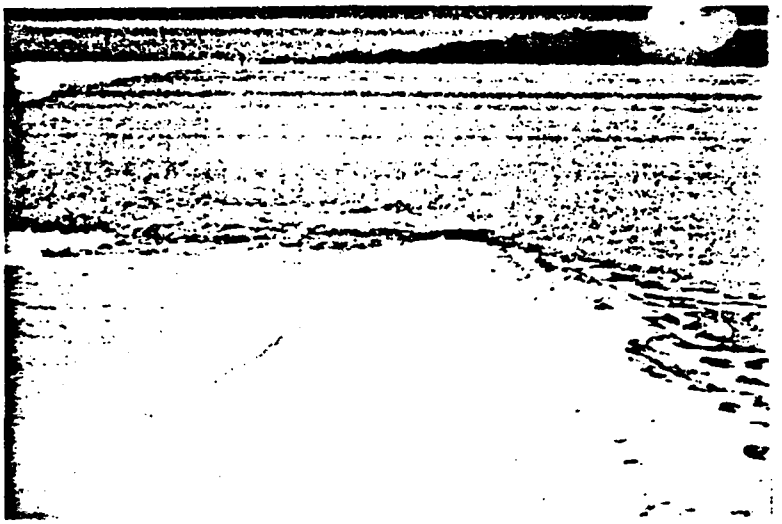


Photo 23 : At its western extreme, Yellow Beach tapers into a rocky point covered with low, thick vegetation.

Photo 24 : Yellow Beach shares with Turtle Beach the distinction of being the best area for sea turtle nesting; even so, the odds of encountering a nesting turtle on any given night are small.

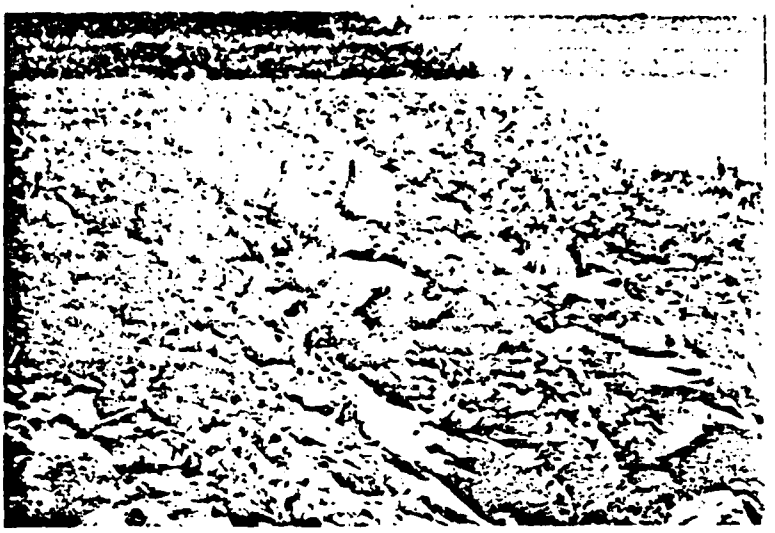


Photo 25 : *Melocactus* is prominent on the rocky slopes at the east end of Yellow Beach.

Photo 26 : Blue Beach, a long beach varying from only a few meters wide to more than 50 meters. Although apparently ideal for sea turtle nesting, none took place there.

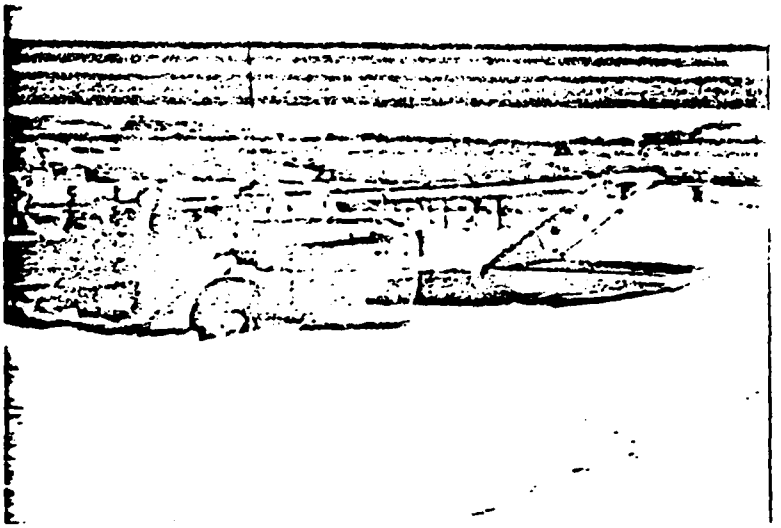


Photo 27 : Landings and subsequent maneuvers are frequently carried out on the wide western end of Blue Beach. Vehicles such as these amphibious craft create a significant impact on the beach.

and

Photo 28

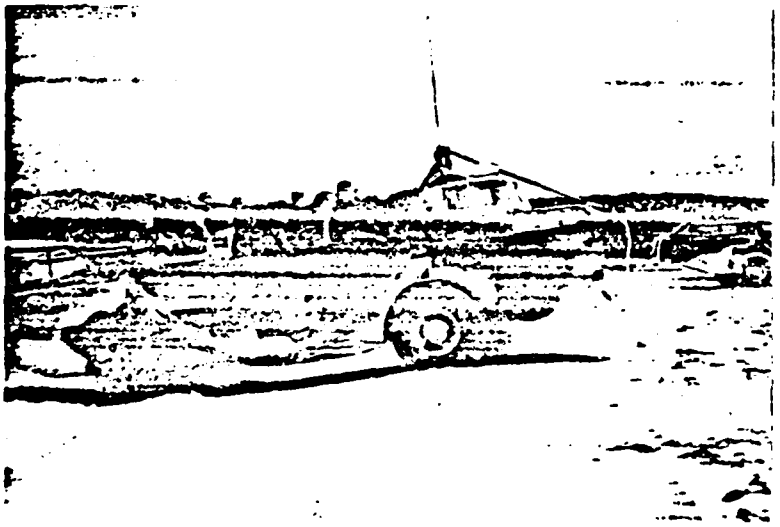


Photo 29 : Foot patrols associated with maneuvers are probably of no great environmental concern.

Photo 30 : Red Beach, popular with civilians, is also a site for maneuvers.

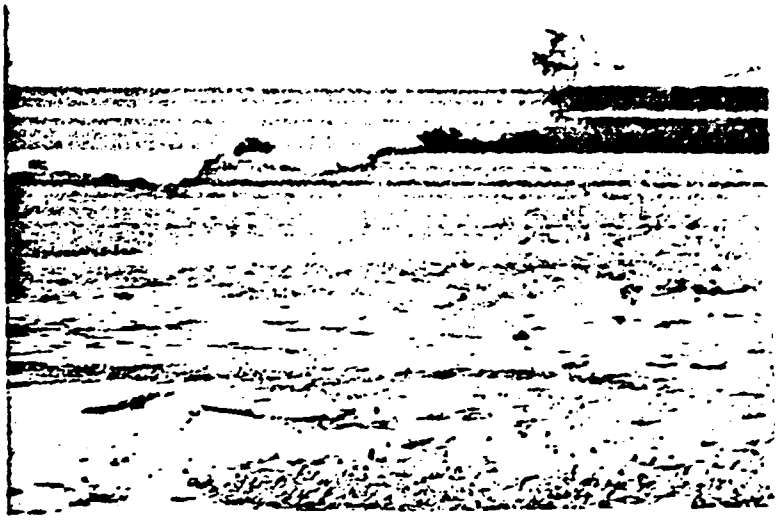


Photo 31: Garcia Beach, adjacent to Red Beach, is a short, broad beach hosting an extensive growth of morning glory(*Ipomea pes-caprae*).

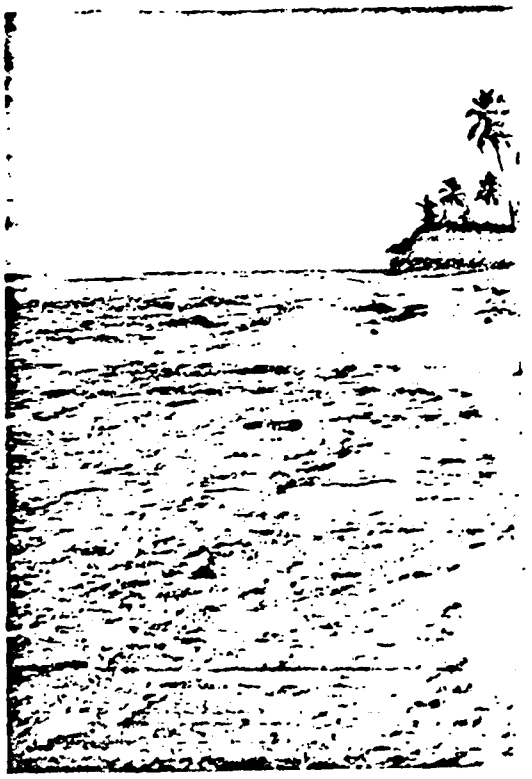


Photo 32 : P'aya Grande Sur, a long beach beginning near the south border of the Naval Ammunition (NAF), is bordered by rock shelf that would discourage any but the most intrepid Hawksbill.

Photo 33 : The southeast coast varies from broad flat stretches to beaches only a meter wide.

Photo 34 : Jagged groupings of weathered granite characterize the southeast coast.

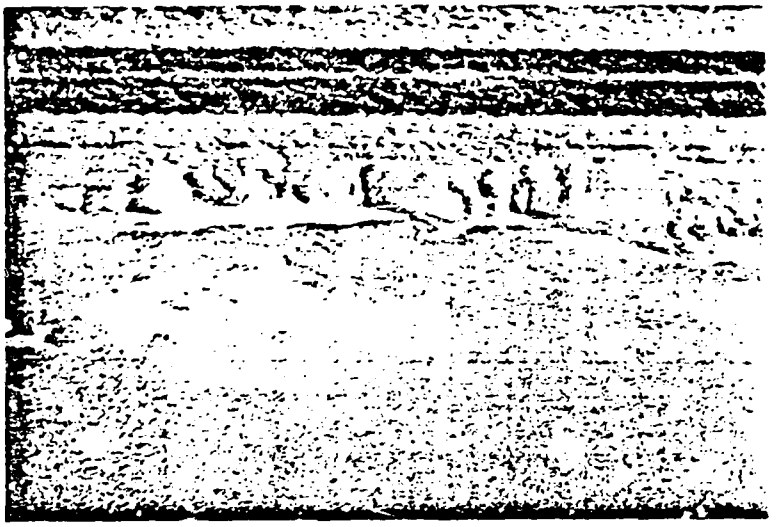


Photo 35 : Steep granite cliffs delineate and separate the beaches along Vieques' southeast coast.

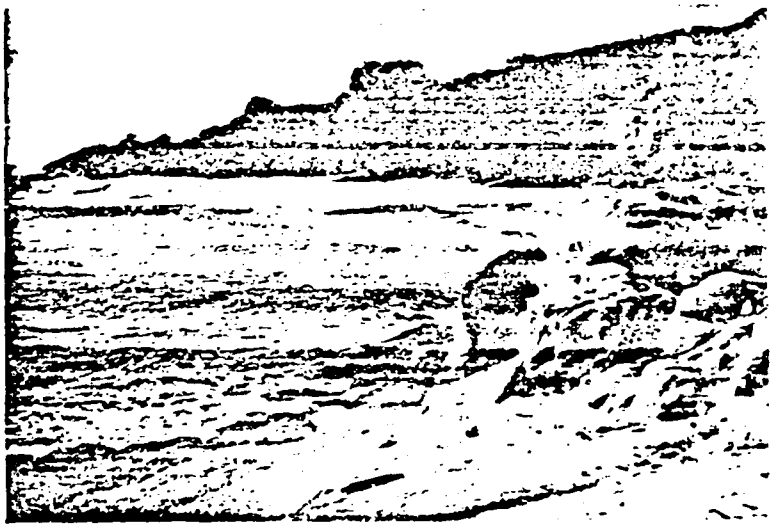


Photo 36 : Beaches such as this provide suitable habitat for Hawksbill nesting along the southeast coast.

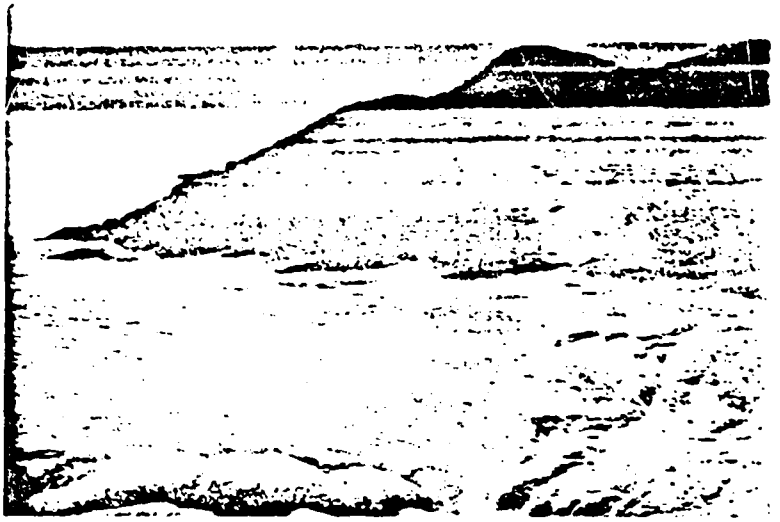


Photo 37 : Many of the southeast beaches are too narrow to be adequate nesting sites.

Photo 38 : Rock obstructs access to beach areas - usually partially, but in some areas entirely.

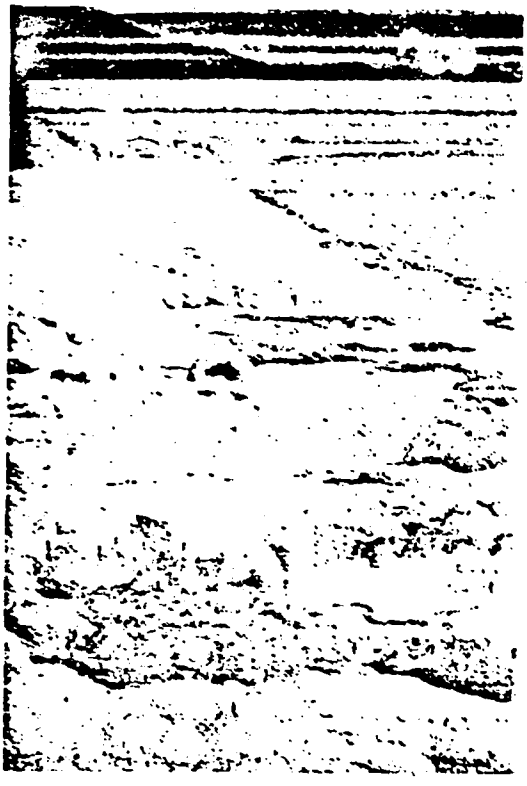


Photo 39 : The above beach is both sufficiently wide and clear of access to provide an acceptable nesting environment.

Photo 40 : A very fine beach sand is found as a component of some of the southeast coast beaches.

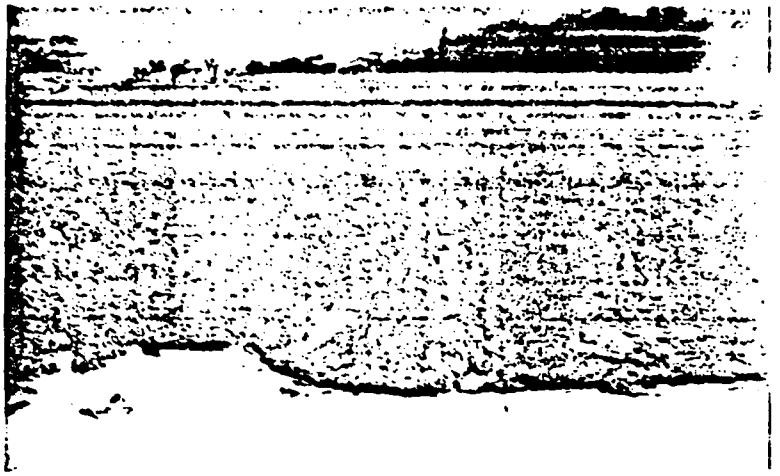


Photo 41 : Seagrapes (*Cocoloba uvifera*) and *Plumeria* are abundant fringing vegetation on the southeast coast.

Photo 42 : Rocks and large pebbles along the shoreline may discourage and [illegible] turtles in some areas.

Photo 43 (see next page)

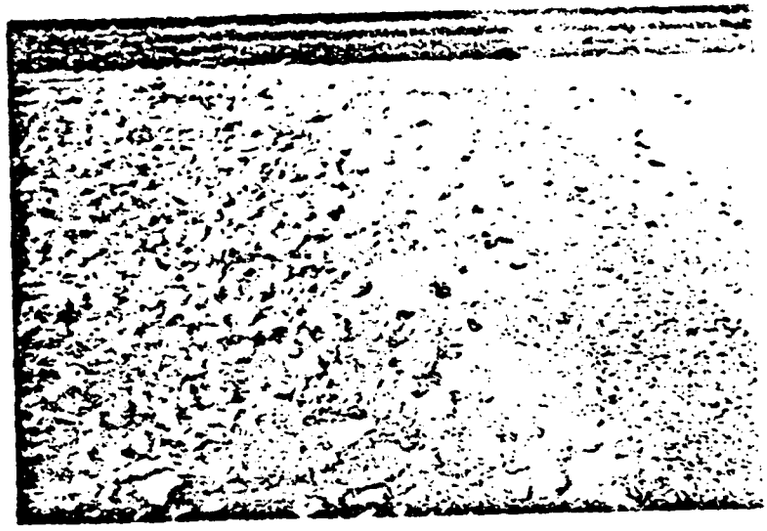


Photo 43 : (See Photo 42)

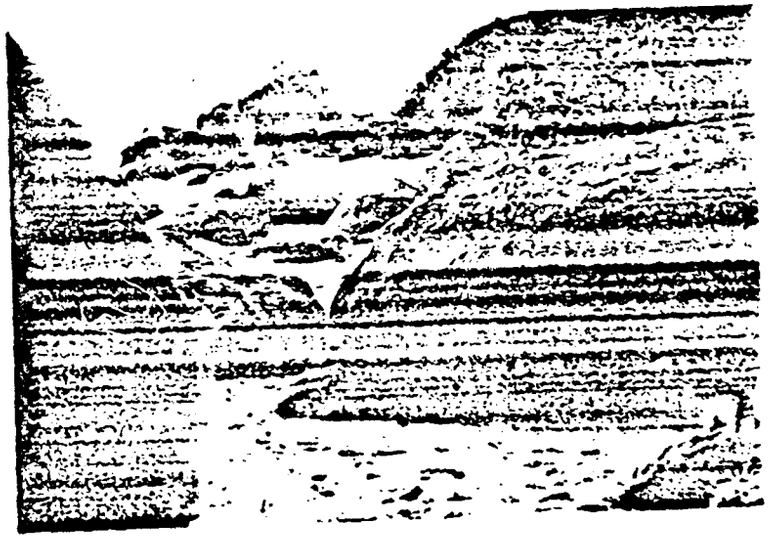


Photo 44 : At the southwestern extreme of Vieques, aggregations of huge boulders punctuate the beach.

Photo 45 : A Hawksbill nest on the southeast coast yielded 178 eggs.

Photo 46 : The nest was placed in a rather narrow niche next to the landward border of the beach, illustrating Hawksbills' relatively eclectic approach to finding nesting sites.

6.1.3. EVALUATION OF NESTING SUBSTRATES

Sea turtles apparently nest successfully on a wide variety of beach substrates. Physical factors which could conceivably affect the hatching success of a given turtle nest include the following:

i) Temperature
ii) Moisture conditions and hur 'dity
iii) Erosion
iv) Chemical and physical properties of substrate.

i) Temperature:

Temperature related aspects of sea turtle development are discussed by Mrosovsky (1980). As would be expected, at constant temperature incubation proceeds faster when the temperature is higher; generally over a range of 26-32°, a 1° C decrease in temperature adds about 5 days to incubation time. Bustard (1972) reports that green turtle eggs artificially incubated in Australia hatched after 80 days at 27°C, after 55 days at 30° C, and after 48 days at 32° C. Constant temperature, however, is unlikely to be present in natural nests. While the protective layer of sand over the eggs shields out almost all diurnal/nocturnal fluctutation, as incubation proceeds temperature does increase within the egg mass, and the eggs nearest the center of the clutch generally are exposed to the highest temperatures.

Under extreme circumstances, the incubation time in natural nests can be excessively prolonged. Natural nests normally hatch after 50 to 65 days, with some variation with species; incubation times in different places and for different species are summarized by Hirth (1980). However, tropical beaches,

or subtropical beaches during the summer months, have a fairly impressive uniformity of temperature at the depth of turtle nests, and natural variation in incubation time is modest except for cases where nests in the subtropics were laid so late in the season that they were exposed to cool fall temperatures. Perhaps the most dramatic example of this on record is that recorded by Dalrymple (1982), who found a nest of the normally tropical Hawksbill on Soldier Key near Miami, Florida, on October 22, 1981. This was not only the first absolutely confirmed record of the Hawksbill nesting in Florida, but also by far the latest nesting for any sea turtle in the continental United States. Some of the eggs were artificially incubated in the laboratory; however, those that were left in the natural nest showed an extraordinary incubation time of over 90 days. This attenuation of development time was correlated with various severe abnormalities in the hatchlings, all of which suffered an early demise.

While extremes of temperature may result in extensive or complete clutch failure, and lesser extremes in the kind of abnormalities recorded above, recently study has shown that even slight temperature deviations may show dramatic results in affecting the sex ratio of the hatchlings. Yntema and Mrosovsky (1979) present a graph that suggests that controlled incubation temperatures of 26 or 28° produce 100% male turtles; at 30°, about 70% females are formed; and at 32° to 34°, 100% females are produced.

The evolutionary implications of this are far-reaching though largely speculative at present. It is not yet known if the species wide sex ratio tends towards equality or is significantly skewed. However, it is possible that adult sea turtles tend to have mortality rates that are not only significantly different but also variable and unpredictable. For example, female turtles on beaches under some circumstances may undergo heavy mortality from

large mammalian predators (including man), or from encounters with inanimate obstructions (logs, rocks, etc.). A mechanism that would permit a population to restore the depleted sex following episodes of differential mortality would certainly be of great benefit to the species, and if, for example, a female that was harrassed by excessive numbers of males prior to nesting were to climb less far up the beach and deposit her eggs in an area that was always exposed to full sun rather than partially shadowed by vegetation, the eggs would produce a majority of females that would serve to correct the disproportion. Another conceivable mechanism might be for females on a beach where they were subject to heavy predation to nest in more open areas, closer to the sea, rather than the more inland areas where they might be closer to lurking predators and where the retreat path to the sea if they were disturbed would be longer.

A fixed mechanism to produce a preponderance of females would be counterproductive because major losses of nesting females do not always happen. However, these mechanisms are all speculative for the present, and indeed the study of temperature-dependence of sex in hatchling turtles is still in its infancy. We know of no reason to feel that sea turtle nests in Vieques beaches are subject to any factors, natural or artificial, that would tend to skew the sex ratio, especially since the beaches with vertical cliffs behind them, which might provide an unusual degree of shading, such as the one finds on the south-western part of the island, are rarely used by nesting turtles.

ii) Moisture conditions and humidity:

The effects of humidity upon the viability of eggs of the Loggerhead turtle (*Caretta caretta*) have been investigated by McGehee (1980 - M.S.

thesis, University of Central Florida). Basically, a turtle egg is surrounded by a semi-permeable membrane that will subject the contents to fatal dehydration when exposed either to non-saturated air or to sea water. On the other hand, immersion in fresh water will cause water intake and unnatural, ultimately fatal, turgor of the egg. In most beaches, the sand at nest-depth has a suitably high humidity to avoid evaporative water loss from the egg. However, osmotic water loss will result if high tide reaches the nest; this is one of the most important constraints forcing turtles to nest above high tide, though surprisingly often they nest too low and the eggs are lost. In extreme cases, sea turtles have been seen digging their nests so low that the cavity immediately fills with water.

iii) Erosion:

In some parts of the world loss of turtle nests to erosion is critical. In the Guianas, the Principal Investigator has observed a major fraction of the season's egg production of Leatherbacks and Green turtles lost as the beaches are swept away by the Equatorial Current, and in certain years (e.g. 1980) hurricane-driven erosion may entirely remove the sand from Aves Island, a small sandbank harboring the major Green turtle breeding population in the eastern Caribbean, with consequent loss of all the eggs then under incubation. Very recent information also suggests that Maziwi Island, off the coast of Tanzania, a major nesting island for three species of sea turtle, has entirely disappeared (UPI wire service info, March 1982).

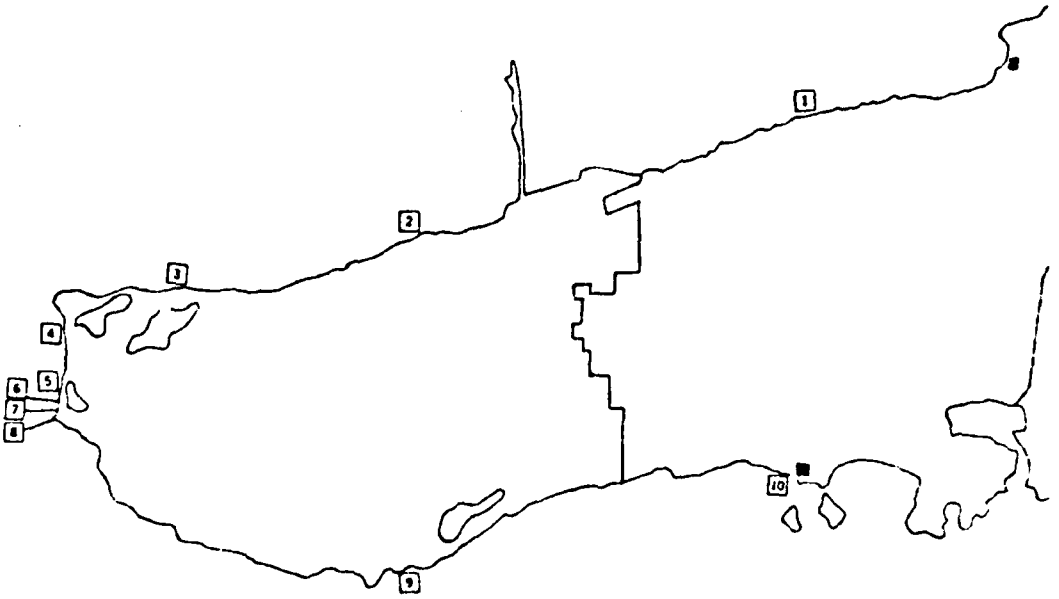
On Vieques, erosion only appears to be serious on Turtle Beach. We saw no evidence that nests were lost to erosion on that beach, but it could happen.

iv) Chemical and Physical Properties of Substrate:

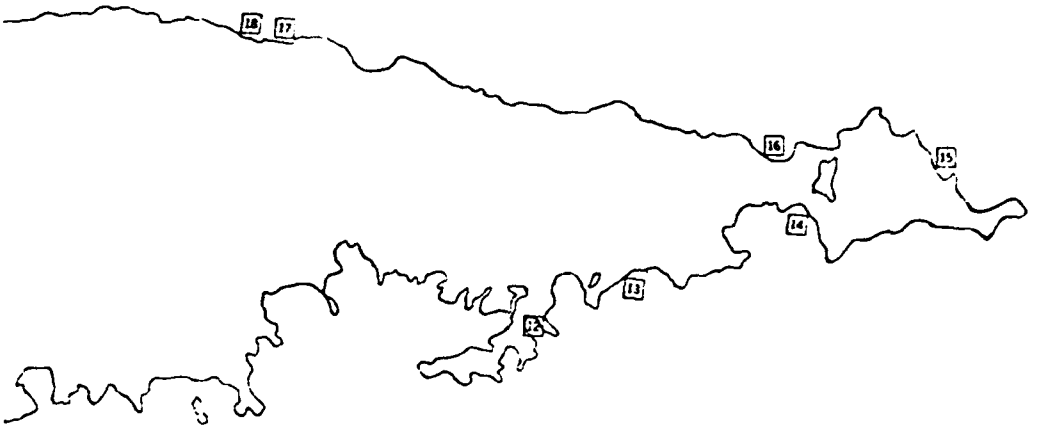
Chemical characteristics of beach sand may influence turtle egg incubation, but no experiments were conducted in the course of our study. It was formerly postulated that turtle hatchlings contained more calcium than the egg from which they hatched, which requires the explanation that the calcium was drawn from outside the egg, which in turn presupposes that the egg was in calcareous rather than silica sand (Bustard et al., 1969). However, it is now recognized that turtle eggs will hatch equally well in pure silica sand or in inert, artificial media; and indeed, it should be remembered that in an undisturbed turtle nest, most of the eggs are in contact only with each other, and have air spaces rather than sand between them.

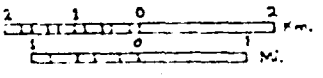
Certain physical characteristics of the substrate may be of importance to the success of incubating turtle eggs. It has been reported, though also denied, that one of the nesting beaches on Ascension Island is composed of such fine volcanic dust that eggs incubating in it were "choked" and never hatched.

Detailed sedimentological studies were conducted of the sand on a number of Vieques beaches in the course of the present study. Samples were collected from the sites shown in the following map (see page 56); they were generally taken from just below the surface from the part of the beach where turtles were assumed to nest. Grain size was established by sifting the sand through sieves of different guage, and establishing the overall weight of the fraction that passed through each guage. Results were expressed on the standard Phi scale (negative logarithm of diameter in mm). Findings for each sample are shown on the following pages (see page 57).



SAND SAMPLE SITES





5EA

SEDIMENTOLOGICAL ANALYSIS

TABLE NUMBER ONE

Phi size at end of interval	Sample Number	-3	-3	-2	-1	0	+1	+2	+3	+4	+5
Weight of sediment in interval	1	0	0	0	0	0	0.4000	11.6750	8.9570	0.0070	0.0
Percent of sediment within interval		0	0	0	0	0	1.9012	55.4922	42.5733	0.0333	0.0
	2	0	0	0	0.3620	0.4560	5.5360	7.8260	0.9580	0.3130	0.0
		0	0	0	2.3429	2.9153	35.8294	50.6504	6.2002	2.0258	0.0
	3	0	0	0	0.1270	0.1360	4.3660	6.5380	1.1950	0.0	0.0
		0	0	0	0.9627	7.3226	33.0958	49.5603	9.0585	0.0	0.0
	4	0	0	0	8.7700	17.7700	0.9400	0.0880	0.0100	0.0	0.0
		0	0	0	31.8007	64.4355	3.4085	0.3191	0.0363	0.0	0.0
	5	0	0	0	8.8040	6.2100	16.0130	2.6880	0.1920	0.0	0.0
		0	0	0	25.9651	18.3148	47.2263	7.9276	0.5663	0.0	0.0
	6	0	0	0	0	5.6940	20.5720	1.1460	0.0670	0.0	0.0
		0	0	0	0	20.7213	74.8645	4.1705	0.2438	0.0	0.0

TABLE NUMSER ONE(continued)

Phi size at end of interval	Sample Number	-3	-3	-2	-1	0	+1	+2	+3	+4	+5
Weight of sediment in interval	7	0	0	0	0.0960	1.6690	16.5030	15.5260	1.4670	0.0	0.0
Percent of sediment within interval		0	0	0	0.2723	4.7333	46.8024	44.0317	4.1604	0.0	0.0
	8	0	0	0	6.9740	13.2650	3.8460	2.0480	0.3000	0.0	0.0
		0	0	0	26.3837	50.1835	14.5500	7.7479	1.1349	0.0	0.0
	9	0	0	0	8.7300	6.6000	9.9080	5.3340	2.3950	0.0	0.0
		0	0	0	26.4810	20.0200	30.0543	16.1798	7.2648	0.0	0.0
	10	0	0	0	0.1580	1.2350	5.5750	9.5630	2.2270	0.0	0.0
		0	0	0	0.8423	6.5839	29.7207	50.9810	11.87[illegible]	0.0	0.0
	11	0	0	0	0	0.0200	0.4120	11.4630	4.1770	0.0	0.0
		0	0	0	0	0.1244	2.5635	71.3228	25.9893	0.0	0.0
	12	0	0	0	0	0	0.0100	16.1590	4.295[illegible]	0.0	0.0
		0	0	0	0	0	0.0489	78.9631	20.9881	0.0	0.0

TABLE NUMBER ONE (continued)

Phi Size at end of Interval	Sample Number	-3	-3	-2	-1	0	+1	+2	+3	+4	+5
Weight of Sediment in Interval	13	0	0	0	0	0.1430	3.3010	13.1380	3.8300	0.0	0.0
Percent of Sediment within Interval		0	0	0	0	0.7006	16.1719	64.3642	18.7635	0.0	0.0
	14	0	0	0	0.0150	0.0990	0.7750	4.9970	11.3420	0.0	0.0
		0	0	0	0.0871	0.5746	4.4985	29.0051	65.8347	0.0	0.0
	15	0	0	0	0	0.0200	1.9140	17.9310	0.6400	0.0	0.0
		0	0	0	0	0.0975	9.3343	87.4470	3.1212	0.0	0.0
	16	0	0	0	0.0350	1.3010	9.3010	6.2190	0.1310	0.0	0.0
		0	0	0	0.2060	7.6588	54.7537	36.6104	0.7712	0.0	0.0
	17	0	0	0	0	0.0380	0.7250	11.2490	5.3420	0.0	0.0
		0	0	0	0	0.2190	4.1777	64.8208	30.7825	0.0	0.0
	18	0	0	0	0	0.1250	2.0400	13.2990	8.6360	0.0	0.0
		0	0	0	0	0.5187	8.4647	55.1826	35.8340	0.0	0.0

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6.2. AERIAL SURVEY RESULTS

Aerial surveys proved to be easily the most effective survey technique for both turtles at sea and for turtle nests. However, apart from a helicopter tour at the beginning of the project, naval aircraft were not available for surveys. We decided in late July that such surveys were essential for completion of the project, and Stubbs joined the Roosevelt Roads flying club at that time for this purpose. Regular flights were conducted during the months of August and October; a combination of sickness and family reasons prevented surveys during most of September, but one flight was made to cover both Culebra and Vieques in late September.

Turtle nesting throughout the year 1980-1981 on Vieques was recorded as follows:

October 1980	None
November	None
December	1 (Hawksbill)
January 1981	None
February	None
March	None
April	1 (Leatherback)
May	7 (3 Leatherback, 3 Hawksbill, 1 probably Green)
June	14 (7 Leatherback, 5 Hawksbill, 2 probably Green)
July	14 (8 Leatherback, 6 Hawksbill)
August	8 (4 Leatherback, 4 Hawksbill)
September	6 (+2?) (2 Leatherback, 3 Hawksbill, 1 probably Green)
October	2 (1 Leatherback, 1 Hawksbill)

Nests were identified on the basis of track width and form; Leatherback tracks are very wide (about 2 meters), tend to include tight, complete circles, and have parallel rather than alternating flipper marks. Hawksbill tracks are narrow (less than 90 cm), light, and have alternating flipper impressions. Green turtle tracks are somewhat wider - usually over 1 meter - relatively heavily cut, and have parallel flipper impressions.

However, because alternation versus parallelism of flipper impressions is not always possible to discern, and because Loggerheads are approximately the same size as green turtles, it is possible that some of the tracks identified as "probably Green" could have been made by Loggerheads.

In nearly all cases, tracks seen from the air were confirmed by a ground visit as soon as possible.

In addition to the counts of turtle nests, turtles themselves were spotted and recorded in the course of flights. Soemtimes a turtle was only visible for a second or two before it dived, and identifications were not always certain. Sightings can thus be broken down as follows:

Category 1: A definite turtle sighting with species recorded with reasonable certainty.
Category 2: A definite turtle sighting but with species uncertain.
Category 3: A probable turtle sighting (i.e. a turtle-like object spotted on the surface of the water, but for too brief a time for absolute confirmation that it was indeed a turtle).

As mentioned above, aerial surveys were concentrated in the months of August and October. In each of these two months, approximately 20 hours survey (flight) time was logged. In all cases flights were made very early in the day (7-9 a.m.) in order to advantage of several factors, namely i) the low angle of the sun which places turtle tracks in strong relief with good shadows; ii) freshness of tracks from the night before, so that they can be logged before they have eroded by the tide or rain; and iii) relatively calm morning water conditions, which maximizeschances of turtles being both on the surface of the water and being spotted - turbulent water not only results in fewer turtles being on the surface, but the resultant glare and disturbance makes it difficult to see those few turtles that are on the surface. All parameters were kept as closely comparable as possible during the two months of observation. Nevertheless, distribution and abun-

dance of turtles during these two months was very different. During August, 18 turtles were spotted, of which 12 were in the waters adjacent to the bombing range and 6 were elsewhere around Vieques. However, in October 80 turtles were spotted (i.e. slightly better than four times the turtles/unit time ratio recorded in August), and of these only 11 were in range waters, and 69 elsewhere around the island.

Facile and definite interpretation of these strikingly different results is difficult. Too little is known of quantitative aspects of aerial survey as a means of evaluating turtle distribution; the percentage of turtles in a given population that is visible on the surface at any one time is unknown, and clearly varies with meteorological conditions, time of day, and species. Moreover, nearly all turtles seen from aerial surveys appear to be of adult or near-adult size, yet underwater surveys of reefs reveal that populations of Hawksbills, at least, typically include a large percentage of juveniles. Young turtles may thus either not spend much time on the surface or are too small to be recorded from the 300-500 ft. typical survey altitude. For the time being therefore we must record the raw data as clearly as we can, and present some cautious interpretation without indulging in unjustified speculation.

6.2.1. The following series of maps shows the distribution of turtle nests observed on Vieques during 1981.

NESTS

● Hawksbills

▲ Leatherbacks

■ Green

□ Green or Loggerhead

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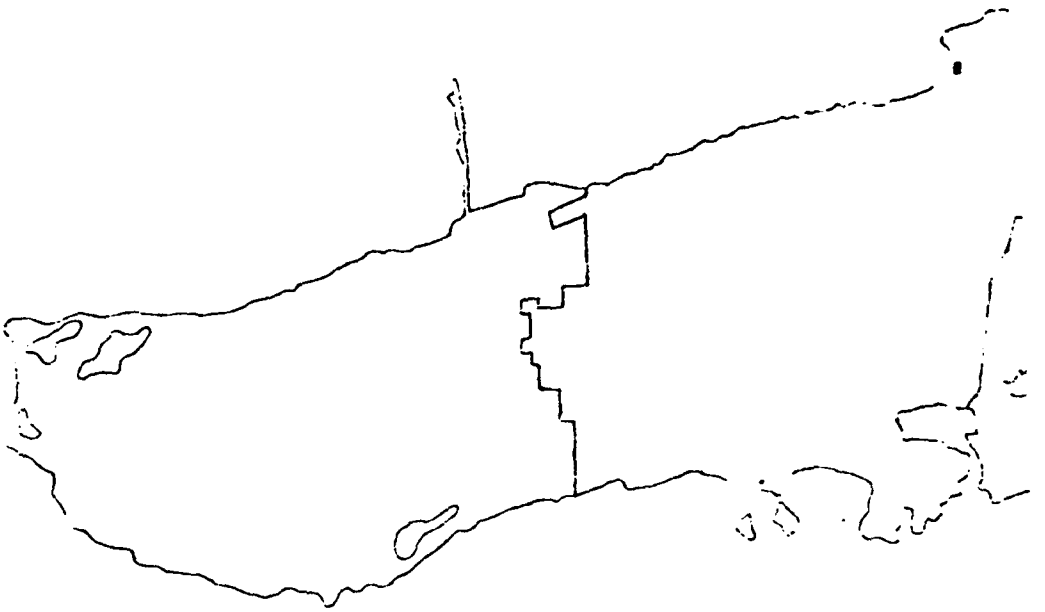
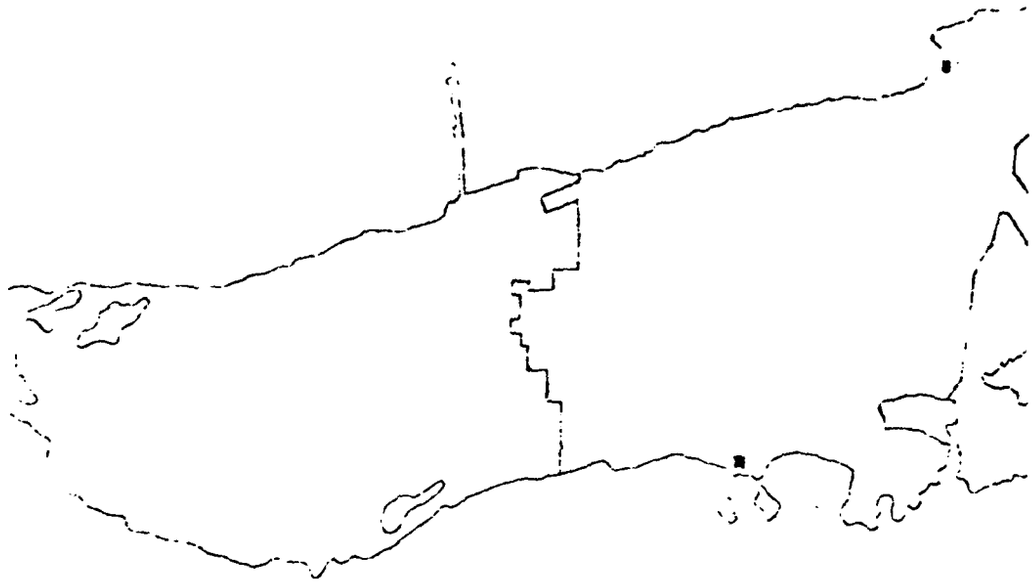
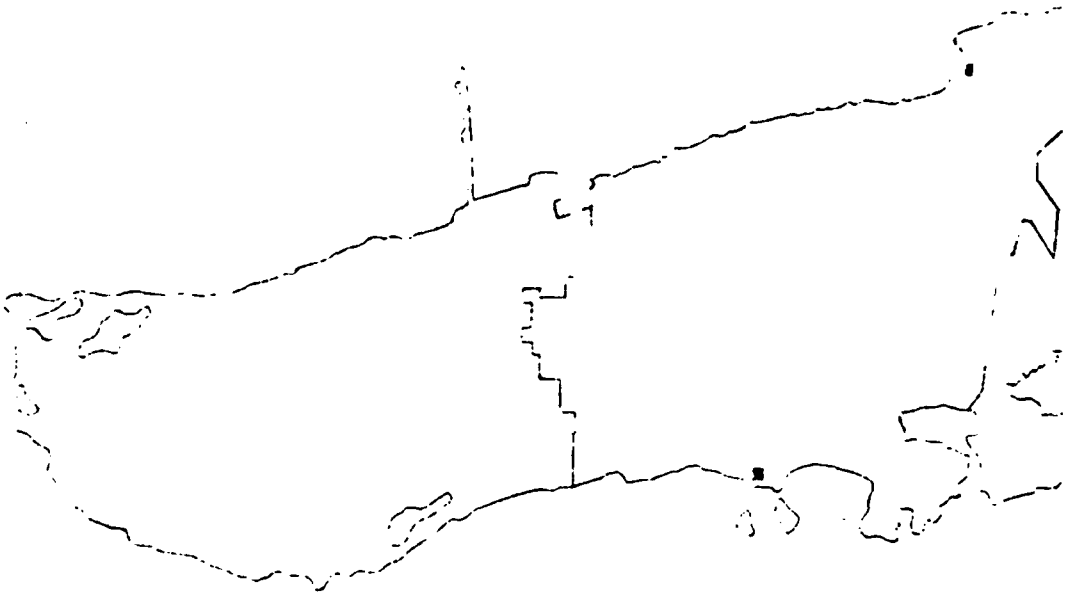


APRIL

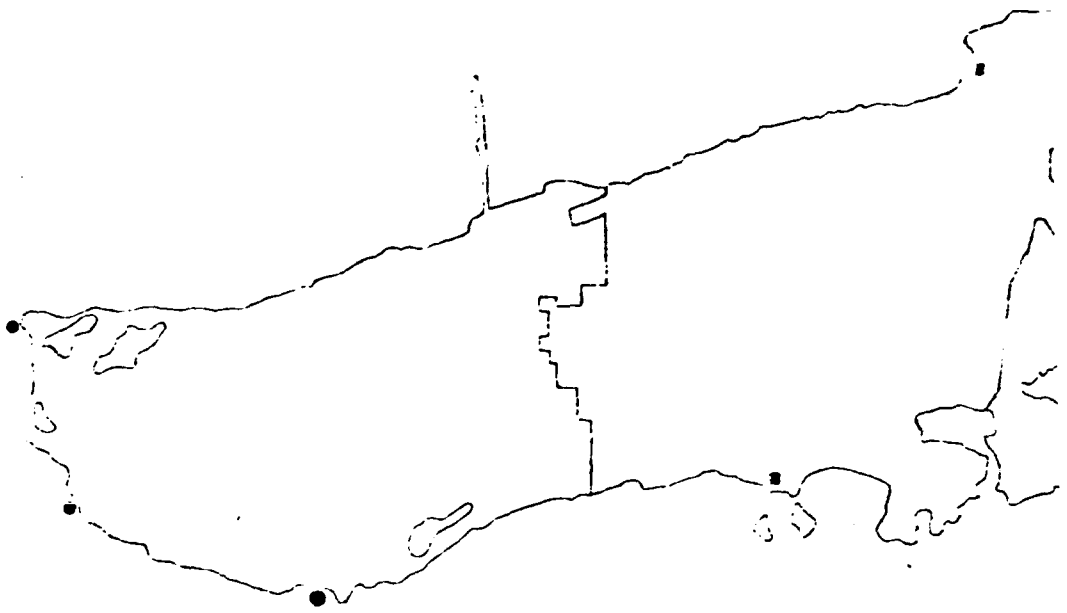


MAY

G5A



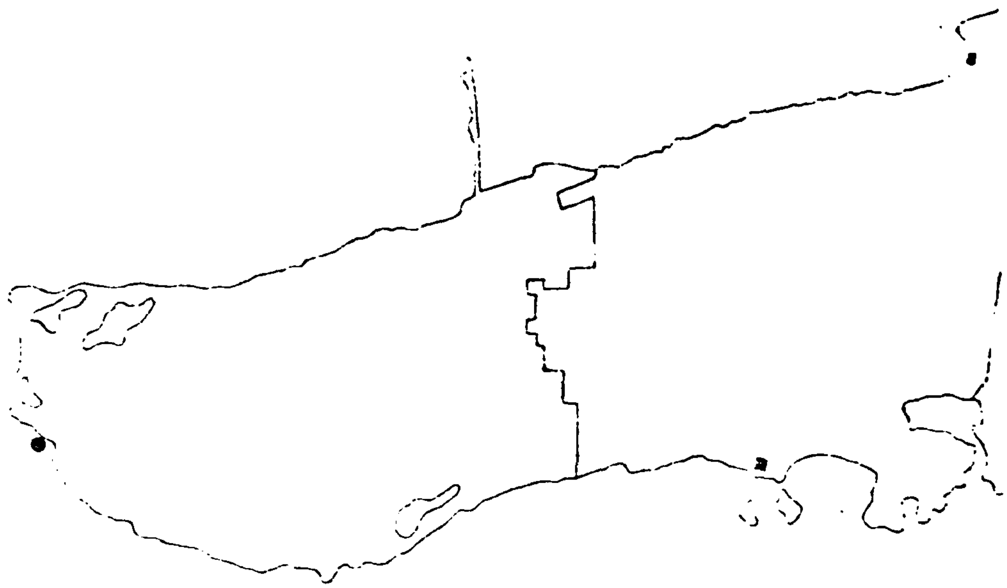
JUNE



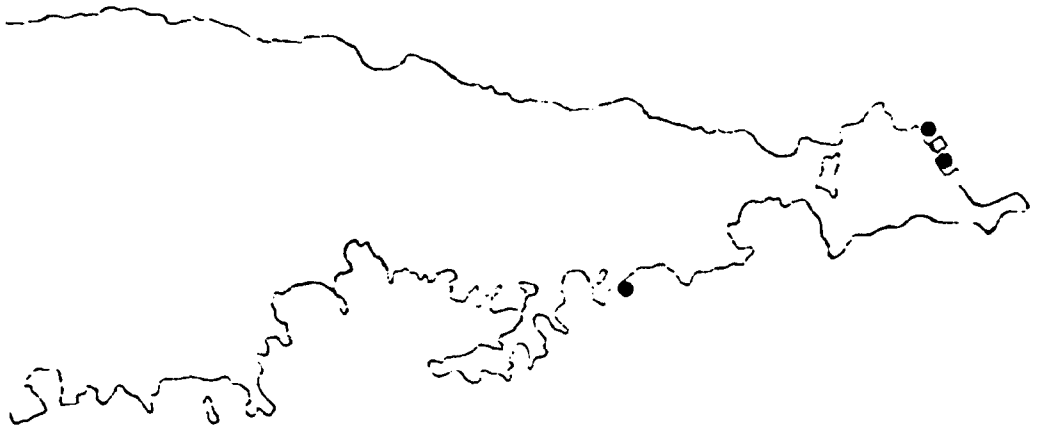
JULY

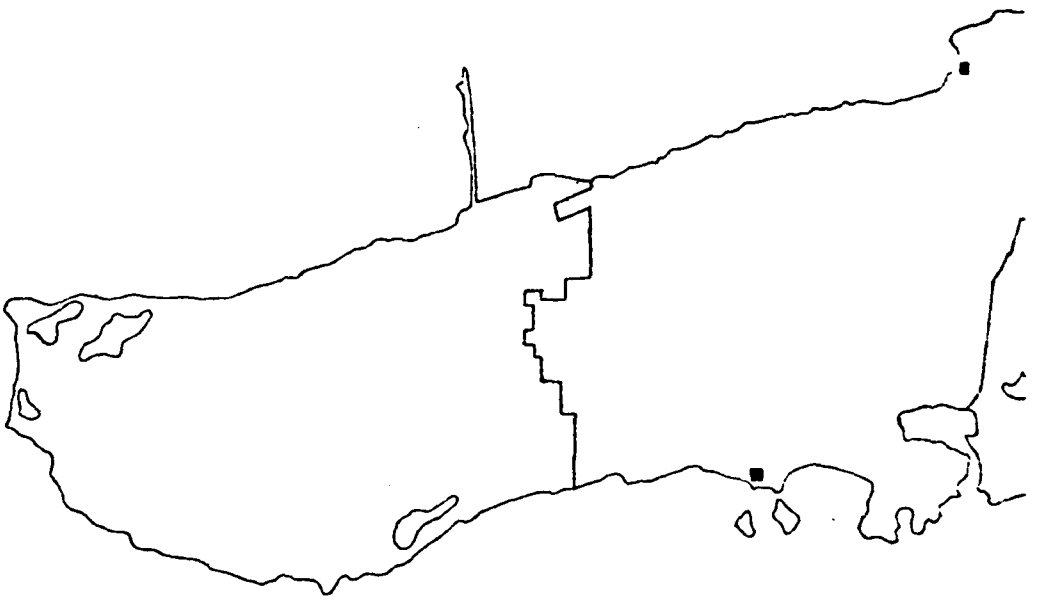
AUGUST

GPA



SEPTEMBER





OCTOBER

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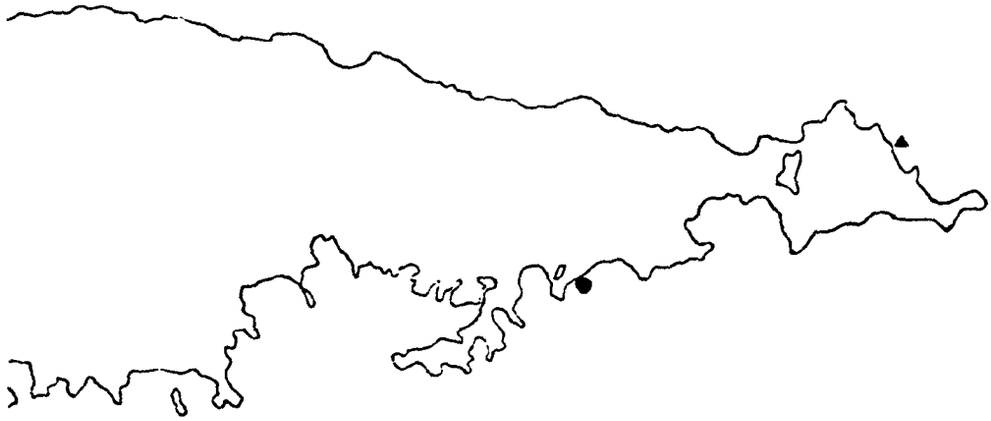

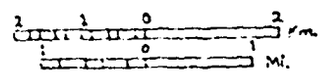

70A

6.2.2. The following maps illustrate observations of turtles at sea in the course of aerial surveys in 1981. The number in each case refers to the particular flight during the month in which the turtle was spotted (e.g. a 7 on the November map refers to a turtle obser at this location on the seventh survey during the month of November.)

AERIAL SURVEY SIGHTINGS

August Map	Date
1	18 August 1981
2	17 August 1981
3	18 August 1981
4	19 August 1981
5	20 August 1981
6	21 August 1981
7	22 August 1981
8	25 August 1981
9	26 August 1981
September Map	**Date**
1	23 September 198
2	29 September 198
October Map	**Date**
1	3 October 1981
2	5 October 1981
3	7 October 1981
4	8 October 1981
5	12 October 1981
6	13 October 1981
7	14 October 1981
8	17 October 1981
9	20 October 1981
10	21 October 1981
11	22 October 1981
12	23 October 1981

13	27 October 1981
14	10 October 1981

November Map	Date
1	2 November 1981
2	6 November 1981
3	13 November 1981
4	15 November 1981
5	16 November 1981
6	17 November 1981
7	18 November 1981
9	23 November 1981

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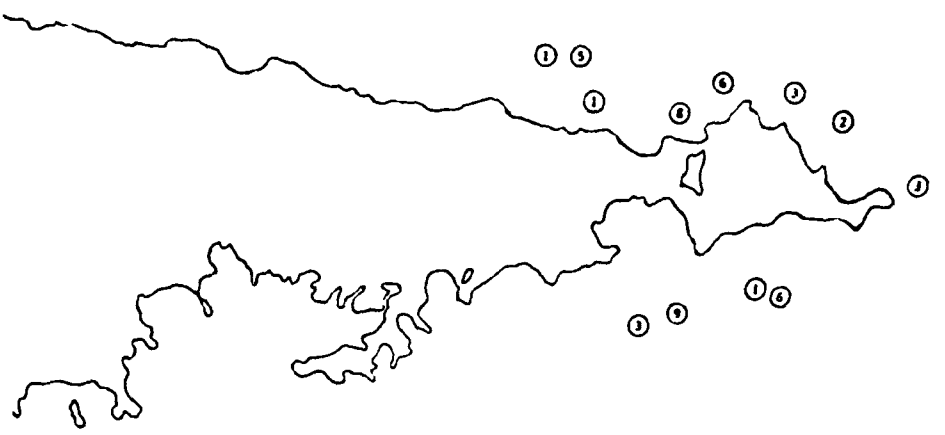
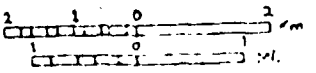
AUGUST





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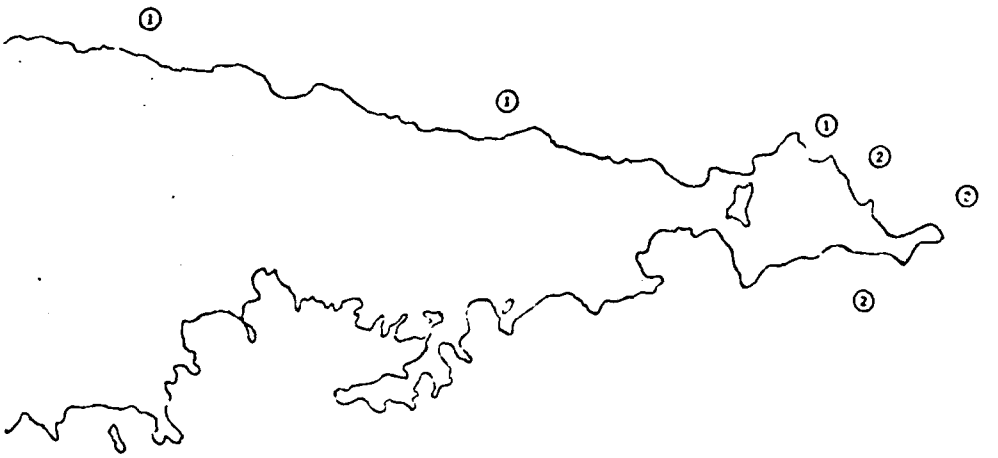
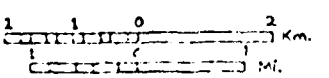
SEPTEMBER

75





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AN EVALUATION OF SEA TURTLE POPULATIONS AND SURVIVAL STATUS ON --ETC(U)
JUN 82 P C PRITCHARD, T H STUBBS N66001-80-C-0560
UNCLASSIFIED NOSC-CR-119 NL

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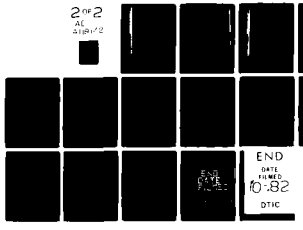

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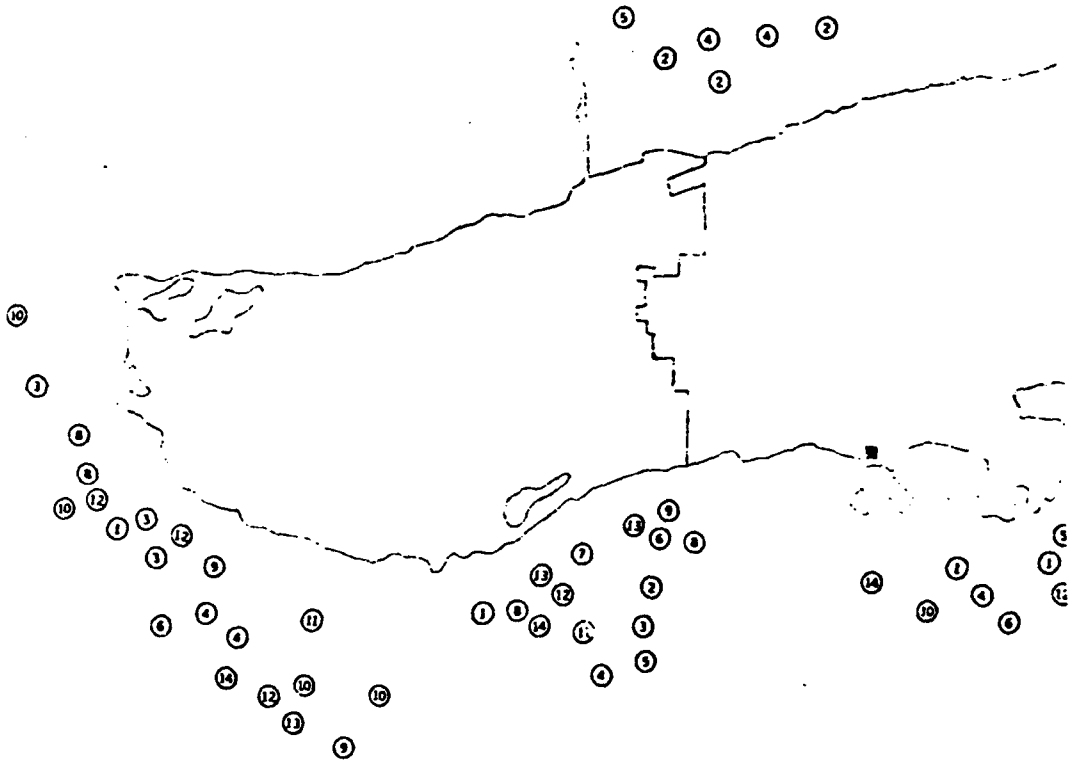
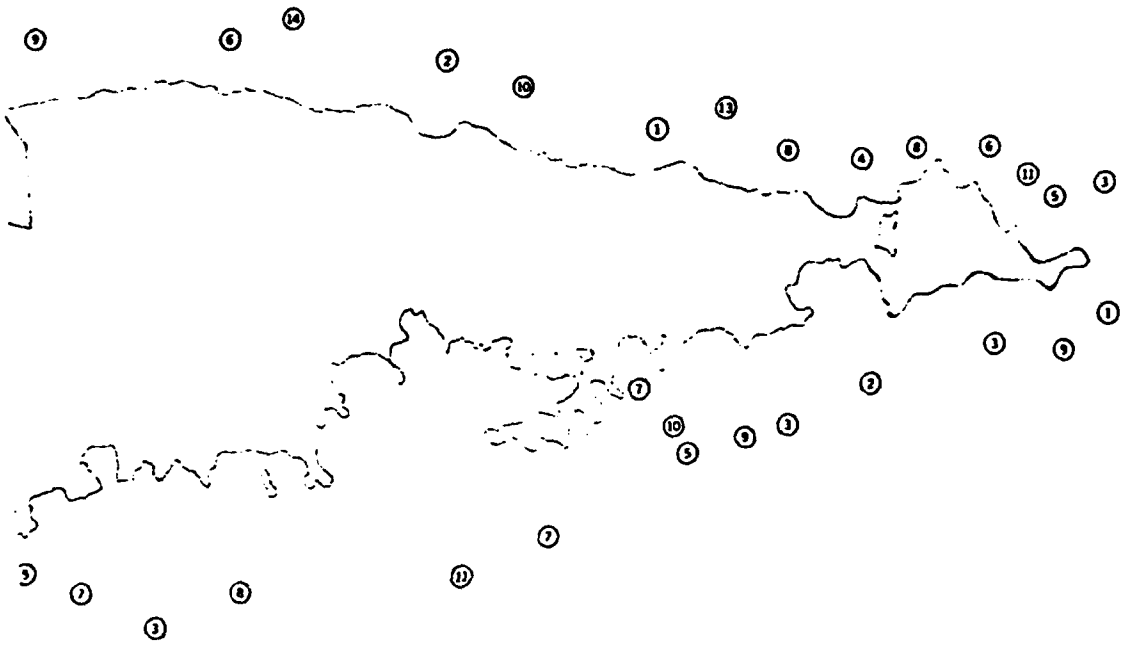


OCTOBER



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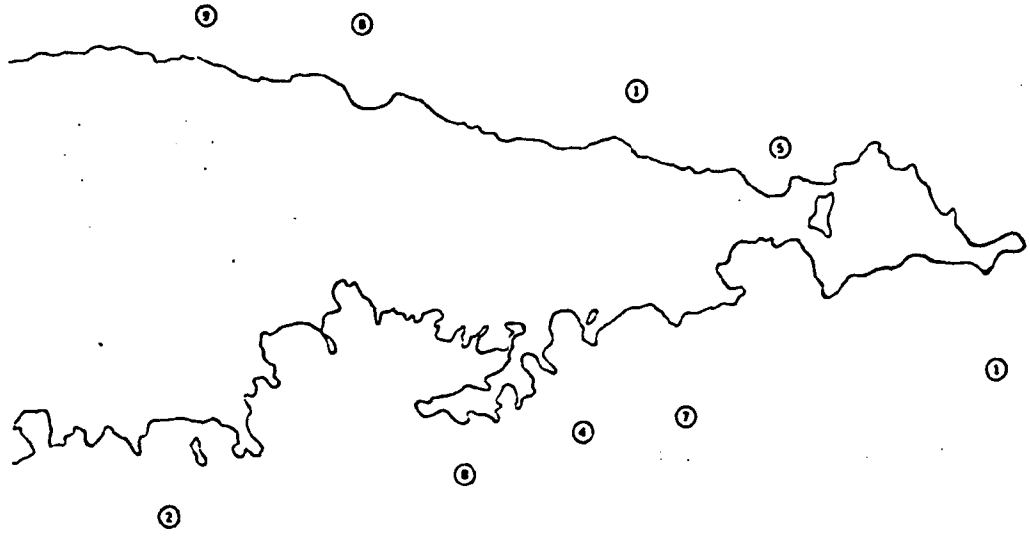

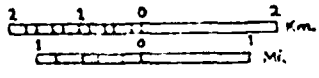

77A

6.3 EFFECTS OF HUMAN ACTIVITY

6.3.1 Effects of civilian activity:

The human population of the civilian third of Vieques is concentrated in two small towns: Isabela Segunda on the north coast and the smaller Esperanza on the south coast. Human effects on sea turtle populations in this area fall into several categories: i) direct predation, ii) damage to beaches and/or turtles caused by feral and domestic animals, iii) effects that are incidental to human activities.

Although all species of sea turtle are protected by U.S. laws, poaching of adults and of eggs of the remaining turtles in Vieques is still common. Although we personally witnessed no poaching on Vieques, we have no reason to doubt the truth of accounts we heard. One acquaintance remarked that "it seems that every time I go into a house in Esperanza someone is cooking turtle."

It was often very difficult to extract precise information from informants, even those we knew well. We often heard of turtles being killed, but when attempts were made to determine specifics, such as the exact beach, day, and who might have been involved, these invariably proved elusive.

This is understandable, especially in consideration of the suspicions about our real purpose on Vieques. Right up to the end of the survey, we were assumed to work for the CIA, Navy Intelligence or the FBI, and this obviously made it difficult for us to get precise information on illegal activities.

The result was that we received many nonspecific accounts of

poaching, but almost nothing that named times, places, and guilty parties. Nonetheless, we assume that a general level of poaching may be interpreted from the heresay. Vieques is an island of limited resources, and we suppose that fishermen and others would not be averse to adding some extra meat to the table. Although all islanders should now be familiar with the law protecting turtles, it still seems that many people will break the law when the opportunity presents, turtles being both a traditional food and a supposed aphrodisiac. On Vieques too, breaking even wildlife laws may be an anti-authoritarian or anti-Navy indulgence.

The perception of sea turtles and their eggs as having aphrodisiac value, a widespread belief throughout the tropics, is an exacerbating factor. The origin of the myth is possibly based in the fact that sea turtles coming ashore to nest would provide a sudden influx of high-protein food in areas where such foods were generally scarce. The subsequent improvement in general health and thus sexual appetite was then thought to be related in some special quality of the turtle.

On Vieques, and indeed in much of Latin America, it is believed by some that consuming the penis of male sea turtles confers enhanced virility; this may stem from the disproportionately large size of this member in adult males of several turtle species.

Human exploitation is still a threat to the turtle populations of Vieques, but we found the situation to be less disastrous than that reported by Rainey (1978) who found that almost no nests escape the poachers. We found nesting to be so diffuse that for most people turtle poaching is simply too unproductive to be much of a temptation, and isolated nests on unfrequented beaches are often overlooked.

Also, the best nesting beaches are on Navy property. Whereas

the protection thus provided is imperfect, it is significant. Assuming that the civilian guards are conscientious, the only beach that is really vulnerable is Turtle Beach, where there was often regular evidence of poaching Because it is on the bombing range the guards do not patrol it, and it is not visible from the lookout station at Cerro Matias.

Legislation, especially without enforcement patrols, will never stop poaching, but at least the commercial market for meat and leather has been vastly restricted since turtle products cannot be openly exposed for sale - though restaurants on Puerto Rico are known still to serve turtle meat to selected customers.

Competition for beach space by humans and incompatible beach uses also present a negative influence upon turtle nesting on Vieques.

Lights are frequently a hazard because they may disorient the nesting females and the hatchlings. On Vieques the glow from the cities of Isabela Segunda and Esperanza reaches a considerable distance, but turtles very rarely nest close to either of these towns.

Feral animals do not appear to be a threat to sea turtle nesting success on Vieques; in many parts of the world dogs and wild pigs dig up turtle nests or eat the young as they emerge, but most of the feral dogs on Vieques make their living at the garbage dump, which offers a much more predictable source of food than scattered turtle nests.

Domestic animals are more of a problem, but the degree to which they really affect turtle nests is still indeterminate. Large numbers of cattle roam the open country of the Navy's property on both ends of the island. In many areas beaches are used as regular trails, and

the runs are close to the vegetation line where sea turtles might be expected to nest.

Unfortunately, controlled experiments have not been undertaken to demonstrate whether or not cattle walking over a turtle nest could break or otherwise harm the eggs within. Certainly, compression damage may occur when extremely heavy objects, such as tanks and other vehicles, compact the sand, but whether a line of cattle walking over a nest is enough to rupture any of the eggs or otherwise kill the embryos is not known.

Vehicles are constantly driven on beaches in the civilian sector, but most of these beaches are too small, difficult of access, or too soft to lend themselves to extensive vehicular traffic of any kind, so this is unlikely to be a significant problem.

At sea, turtles may be caught by fishermen; although illegal, we have not heard of a single case of an arrest being made on Vieques even when indisputable evidence is presented to the authorities.

Turtles may also be caught incidentally in nets that are set out by fishermen for other purposes. This is very difficult to bring under control since the net placement is not illegal in itself. It is to be hoped that the fishermen can be taught to watch out for turtles and to release them when they are caught, but it would be naive to believe that this would be easy to accomplish.

6.3.2 Effects of Naval Activity

Naval activities on Vieques take place both on beaches and in offshore waters. This fact makes the Navy vulnerable to criticism both

from concerned conservationists and political activists. Objective evaluation of the impact of such activities upon turtles was the primary objective of the present study.

Several beaches on the east end of Vieques are regularly used by the Navy for amphibious vehicular operations; in particular, Red , Blue, Yellow, Purple and YFU Beaches. Landings of troops and amphibious vehicles and occasionally tanks have a dramatic and immediate impact on the beaches (see figure 27.). The sand may be deeply gouged by machinery, and the weight of hundreds of men might have an adverse effect on any turtle nests present.

However, we found no nests on Blue Beach or Red Beach during the course of the year, and we doubt if any nesting ever occurs on either of these beaches. Nests on Purple Beach during our study year were restricted to the west end, so if maneuvers are confined to the center section of the beach the possibility of damaging turtle nests will be small. In any case, few turtles nest on Purple Beach - we only found five in 1980-81. But we still recommend that a check be made for visible nests or tracks before maneuvers take place, and protective measures be taken when necessary. Nests should not be moved, but could be conspicuously marked for the duration of the maneuvers on the beach.

Yellow Beach is more critical. It is one of the two most important nesting beaches on Vieques, and needs careful consideration in advance of any military activity. Ideally, it should be exempt from

If this is impossible, the Range Manager should monitor the beach during the nesting season, marking the nests so that they can be protected from the impact of men and machines. The movement of troops and

vehicles should also be limited to the central part of the beach, as most of the nests were near the ends.

Vieques has only a few significant turtle nesting beaches, so each of these needs careful protection. Turtle Beach and Yellow Beach are the most important (though even they are minor by world standards).

Yellow Beach is relatively safe from the possibility of ordnance shortfall; it may happen occasionally, but we saw none during the 1981 season. Turtle Beach is within the limits of the bombing range, but we saw no sign of any explosives hitting this beach in 1980-81 either; it is somewhat east of the area toward which most ship-to-shore firing occurs.

Ordnance had exploded on a few of the northern beaches west of turtle beach, but there was no evidence of nesting on these rather narrow beaches. On a beach where nesting did occur, explosions would be much more likely to destroy nests themselves (which are in place for 8 weeks) than adult turtles (which are ashore only at night, for an hour or two per nesting).

Turtle Beach is a wide, high-energy beach that experiences some degree of erosion and alteration throughout the nesting season, but no visible bombing effects. Possibly the intensive ordnance explosions nearby could have an effect on the eggs; but this beach together with Yellow Beach are still attracting the most turtles of any Vieques beach after more than forty years of bombing, so serious negative impact seems unlikely.

Aside from the landing maneuvers on those few beaches mentioned and the activities on the bombing range, most of the beaches on the east end of the island experience minimal intrusion from the Navy's

presence. However, a potential problem exists with flares over the bombing range and a system of extremely bright lights at Cerro Matias that light up Yellow Beach on occasion. Lights were installed as a safety precaution following terrorist threats to plant explosives at the observation post on Cerro Matias.

These lights illuminate the east end of Yellow Beach so intensively that emerging hatchling sea turtles might well be attracted toward them, becoming lost in the vegetation that fringes the beach. It is therefore recommended that the lights only be used during emergency periods from April through September.

Work by Mrosovsky (1972) indicated that baby sea turtles will orient toward the brightest segment of their visual horizon, so there is no question that the lights at Cerro Matias are a potential hazard. Various studies (Mann, 1978, Carr and Ogren, 1959) have shown that hatchling turtles do not differentiate artificial light from natural. They may even be attracted, fatally, to the light of a beach campfire (Mortimer, 1979).

The light given out by flares on the bombing range, while intense, is unlikely to represent a major problem. Very brief flashes of light, such as lightning do not disorient the hatchlings at all. Flares are of longer duration, but their use is sporadic; only rarely do flares light up the beaches for a significant duration.

The relatively recent installation of brilliant lighting on Cerro Matias is potentially serious. It has been abundantly demonstrated that sea turtles will tend to avoid beaches on which there are fixed lights. (Thurston, 1975; Stancyk and Ross, 1978; Davis and Whiting, 1977) This could happen on Yellow Beach.

Although Rainey (1978) pointed out that any nightime military activities that involve illuminating the beaches might affect timing and distribution of nesting females as well as the orientation of the young, the relatively small number of nests means that in statistical terms the probability is low that any nest would be hatching during such operations. In any event the flares are a reality that is not going to be any less severe in the foreseeable future. Damage to sea turtle populations that may occur from their use may have to be accepted as an exchange for the protection of other beaches on Navy property.

On the Naval Ammunition Facility (NAF), roughly the western third of Vieques, there are few military activities that might affect nesting turtles. Green Beach is a popular recreation spot for both military personnel and civilians; although access is limited at nights, the numbers of people and vehicles frequenting the beach might have an adverse effect on turtle nests. We only saw one nest, however, on the sandy point at the northern extension of the beach; it was difficult to determine if the nest had been disturbed other than by the extensive foot traffic along the beach.

The only military activities that may affect turtles in the water are those related to ordnance projection and the occasional maneuvers on Blue, Red, Purple and Yellow Beaches. The latter cannot really be considered a significant threat, because danger to turtles would occur only in the most incidental of circumstances. Some of the amphibious vehicles used for landings would of course injure a sea turtle if they were to come into contact with one, but of course so might any large vessel.

It has been maintained by political activists and others that bombing activities are destroying reefs and blowing up turtles in the water, as well as damaging nests on the beaches. The last point, as previously discussed, does not appear to be substantiated by the facts.

Reef damage, which could affect the resident Hawksbill population, may be an infrequent result of ordnance falling short of its target, although surely not to a major degree. Goodwin (pers. comm.) found that damage to Vieques reefs was no worse than that observed on reefs at St. Thomas and St. Croix; most of the observed damage was probably caused by the 1977 hurricane.

There is no point in arguing that no sea turtle has ever been killed by an off-target bomb, but the probability is so small as to irrelevant. No evidence appeared during the year of our study to support in any way the contention that sea turtles are regularly damaged by ordnance; the only remains of sea turtles found were a few fragments on Blue Beach some distance from the bombing range, and this was surely the work of poachers; sea turtles rarely die on shore except when entrapped by beach obstacles (e.g. Fretey 1981).

An examination of the map showing areas of ordnance shortfall clearly shows that most of the misses are so close to shore, in areas where turtles did not nest and were not seen in the water, that claims of ordnance threatening sea turtles seem to have little credibility. We approached this possibility objectively, with only an interest in determining exactly what does and does not threaten sea turtles. Ordnance cannot be considered a significant hazard on the basis of our data.

It could be postulated that the noise and vibrations from intensive bombing may cause the turtles to be driven off to the more distant parts

of the island; but the fact that most nesting takes place on or near the bombing range is evidence enough that not even distribution around Vieques is more than temporarily affected. If the Navy's activities were of recent origin, then one might argue that it was too soon for effects to be observed. However, after four decades the Navy's presence seems to represent little more than an irritation, in the sense of local density shifts and so forth, at the worst.

On the basis of what we have observed during 1980-81, there are no data to support claims that the bombing or other activities of the Navy are deleterious to sea turtle populations on Vieques; it is more probable that the military presence provides some umbrella of protection. However, as argued in the section on Recommendations, turtle activity and movements may differ from one year to another, and some degree of ongoing monitoring is essential to confirm our conclusions.

7. DISCUSSION

Vieques does not at present constitute a major nesting ground for any species of sea turtle, though this may not always have been the case. The relative importance of the three species known to nest on the island may be summarized as follows:

i) The Leatherback turtle, *Dermochelys coriacea*. The important Atlantic nesting grounds for this species lie in French Guiana, Surinam, and Nicaragua, with smaller numbers nesting in Guyana, Trinidad, Panama, and formerly Columbia. The species is dependent on steep, wide beaches free from obstructions and with an open approach from the sea. Nesting in the islands, with their typically short, often reef-fronted beaches is thus limited for physical reasons. It is probable also, for reasons argued at length by Pritchard (1979), and confirmed by the arguments of Vaughan (1981), that the few Leatherbacks that nest annually on each of a fairly large number of Caribbean islands (known to include Pedro and Morant Cays, Jamaica, St. Croix, Tortola, Trinidad, Tobago, St. Kitts, Nevis, Barbados, Dominican Republic, St. Vincent, Grenada, Martinique, and Guadeloupe (Caldwell and Rathjen, 1969; Caribbean Conservation Corporation, 1980) do not constitute a series of discrete populations. Rather, it seems likely that the Atlantic system has a few, large Leatherback populations - possibly even only one or two discrete breeding populations in the entire western Atlantic - that tend to concentrate their nesting in major rookeries, but from which individuals may be side-tracked to other nesting grounds for one reason or another - either individuals genetically programmed to be "pioneers", or animals that are

late in migration and are caught with eggs ready to lay while still a great distance from their destination beach.

ii) The Green turtle, *Chelonia mydas*. We can add little to the comments of Rainey (1979) on the probable nature and status of the Green turtle populations around Vieques. The species is unimportant there as a nesting animal, with a maximum of only a handful of nestings recorded annually, and these turtles surely do not constitute a genetically discrete population of any antiquity or significance. The population from which the young Green turtles that are sometimes found around Vieques are derived is unknown; geographically the closest major nesting concentration is on Aves Island, 330 km to the southeast. It is extremely unlikely that the fate of Aves Island as a nesting colonly will be dependent on the fate of the immatures that happen to reside around Vieques.

It is of course possible that the immature Green turtles around Vieques constitute the source of the very few nesting animals on the island; this would be very hard to prove or disprove, since while it would be at least possible to capture some of the immatures and tag them, the chances of witnessing a nesting emergence by any of those turtles when they matured (or indeed of any Green turtle, even an untagged one) on Vieques remain impossibly slim.

iii) The Hawksbill turtle, *Eretmochelys imbricata*. From the point of possible impact of naval activities upon sea turtles on Vieques, this is the most critical species to discuss; it is considered endangered on a world-wide basis by the U.S. Department of the Interior; it is the most plentiful species in Vieques waters and on Vieques beaches;

and it is the least migratory of the sea turtles.

The most important question is whether the Vieques Hawksbill population is a discrete deme, or whether it simply represents part of a Caribbean-wide population that moves freely to re-colonize depleted habitat. The question is a complex one, and a simple yes-or-no answer cannot be given. However the following points are relevant to this discussion:

a) The Hawksbill is less inclined towards colonial nesting than any other sea turtle species; small numbers nest on a vast number of beaches spread through the tropical oceans. Typically these beaches are small, located on islands, and with adjacent coral reefs, but there are many exceptions - for example, Tortuguero Beach in Costa Rica is a black-sand, long, mainland, reefless beach; and Shell Beach, Guyana, is a shell-and-mud mainland beach fronting on a turbid ocean that has no reefs for miles. Yet these are among the better Hawksbill beaches in the hemisphere. Nevertheless, the observation that most nesting emergences of the Hawksbills occur one-by-one on beaches that are generally close to potential or actual feeding habitat has led to the conventional conclusion that Hakwsbills are highly sedentary turtles that do not travel far.

This conclusion may have some, but not universal validity. In the last very few years, several cases of long-distance movements of tagged Hawksbills have become known. These include the following:

i) Turtle beached without nesting at Kerehikapa, Solomon Islands, in December 5, 1976; later was killed at Fishermen's Island, Papua New Guinea, in December 1979. Distance traveled: 1,400 km. (Vaughan, 1981).

ii) Turtle tagged at Sakeman Reef, Torres Strait, Australia, on

March 31, 1979; later nested at Kerehikapa, February 16, 1980. Distance traveled: 3,600 km (Vaughan, 1981).

iii) Turtle tagged off Big Miskito Cay, 64 km NE of Sandy Bay, Nicaragua, on June 22, 1972, found nesting at Pedro Key, near Jamaica, on November 14, 1972. Distance travelled: 496 km. (Nietschmann, pers. comm. to Carr and Stancyk, 1975).

iv) Turtle tagged at Tortuguero, Costa Rica, August 18, 1956, was caught before October 18, 1956, 15 miles north of Puerto Cabezas, Nicaragua. Distance travelled: 385 km. (Carr and Stanck, 1975).

Carr and Stancyk also recorded two more cases of Hawksbills tagged at Tortuguero being caught approximately 385 km. away in Nicaragua.

b) Although copulating pairs of Green turtles are often seen adjacent to their nesting beaches, copulating pairs of Hawksbills are rarely or never seen close to nesting beaches. This suggests (though does not prove) that Hawksbills copulate at some distance from their nesting beaches. This in turn suggests that a female Hawksbill may be mated by a male from some distant population, or that was at least hatched from a site at some distance from that at which the female was hatched. This would result in "demes" losing their integrity within a single generation.

c) Hatchling Hawksbills are essentially planktonic, like all hatchling sea turtles, and are at the mercy of the ocean currents for at least the first few months of life. They are colored almost identically to hatchling Loggerheads *(Caretta caretta)*, which are known to live in Sargassum rafts during their early life, and in which they are effectively camoflaged Young Hawksbills in captivity have recently been shown to feed pre-

ferentially upon Sargassum itself (Buitrago, ms.), so it appears very probable that the early life of a Hawksbill turtle consists of emergence from the nest; a run to the sea followed by brisk paddling for several hours to avoid being thrown back on shore by wave action; a period of passive drifting in Sargassum rafts; colonization of and settlement on a suitable reef developmental habitat; and movement to a nearby nesting beach and reproduction when maturity is reached. Many of these stages are easier to summarize in this facile fashion than to understand properly, but it seems a reasonable scenario that the reef on which a Hawksbill eventually settles may be a long way from the beach on which it hatched since these events are probably separated by at least several months of life during which the post-hatchling turtle is essentially at the mercy of current systems.

d) As a general rule, turtles that are active swimmers or migrants remain relatively or completely free of barnacles and other epizootic organisms (Pritchard and Wood, in prep); those that remain in a relatively sedentary condition, especially in lagoons or estuaries, may become thickly encrusted with barnacles. Quantitive studies have not been conducted on Atlantic Hawksbills to evaluate the relative degree of barnacle encrustation. However, recent studies in the Solomon Islands by Vaughan (1981) show that the nesting Hawksbills there included 53% of individuals with barnacles and the remainder without. Moreover, the turtles with barnacles were of a statistically different shape from those without, having curved length/curved width ration of 1.09 compared to 1.14 for those without barnacles. In other words, the turtles without barnacles tended to have a narrower, or shallower, cara-

pace and thus were more streamlined. Whether this difference is genetic or environmental remains to be determined, but it is of interest that both of the two individuals recorded as making long journeys (to Fishermen's Island and to Torres Strait) had carapaces free of barnacles (though one had nine plastral barnacles), and that the one for which full measurements were available was of the long, streamlined shape.

Immature Hawksbills also tend to have rather clean carapaces, without barnacles, and this may indicate that the majority of these younger turtles are rather mobile. On the other hand, the nesting female Hawksbills in the Guianas usually have some to many barnacles, and this may result from a combination of relatively sedentary life and high biological productivity of the turbid waters in this area. It is unfortunate that we do not have data on the extent of barnacle infestation of the Vieques Hawksbills; because of their low density, we only saw them from the air or their tracks on the beaches, and did not have the opportunity of close examination of specimens in hand.

In favor of the 'deme' theory of Hawksbill distribution are the following observations:

e) Carr and Main (1975) reported that their inspection of farmed turtle stock in the Torres Strait of Australia showed that turtles from particular islands developed distinctive patterns as they grew up; groups of turtles were highly distinctive even if the islands of their origin were only a few dozen miles apart. This suggests extremely stable demes that did not interbreed and that have had established genetic divergence.

f) Hawksbills have, at least on occasion, been found to return to the

nesting beach on which they were tagged in subsequent years for re-nesting. This suggests some nest-seeking philopatry that is compatible with the 'deme' theory.

g) When Hawksbill populations are heavily exploited, they may diminish rapidly. This has happened in several areas where populations were once high, e.g. the Solomon Islands (Vaughan, 1981): the Serrano and Serranilla Banks (L. Ogren, pers. comm.), and the Caribbean coast of Panama (Carr, pers. comm.). On the other hand, if the hawksbills were a continuous population within a given ocean rather than a series of demes, one would expect localized exploitation to result in only gradual decline. On the other hand,

h) Hawksbills have been swimming the oceans for tens of millions of years, and their ancestors have been marine for perhaps 100 million years. On the other hand, beaches and coral reefs are geologically much more transitory phenomena. Consequently, Hawksbills must have <u>some</u> ability to colonize new areas and vacate areas undergoing habitat degradation, or they would have been extinct long ago.

8. INTERPRETATION

Taking all these data together, we can establish a postulate that Hawksbill populations probably include a percentage of sedentary individuals and a percentage of long-distance migrants or wanderers. A given small island or nesting beach will to a significant extent have its own associated Hawksbill population or 'deme', and consequently exploitation patterns in that area will reflect most strongly on the local population rather than on the oceanic stock as a whole. Thus, if a local Hawksbill population is heavily depleted by massive human exploitation of both eggs and turtles, the local populations will be correspondingly depleted for at least a turtle generation of two or more decades. Eventually, however, post-hatchling animals will arrive on ocean currents from other nesting grounds and, if they find a suitable vacant habitat, will take up residence. There may also be a possibility of mature or near-mature turtles 'wandering in' from adjacent nesting grounds and taking up residence in depopulated habitat. We do not know at present how long these two forms of re-invasion would take, but one or the other of them must occur or geologically new habitat would never be invaded.

This postulate seems to argue against the observations in the Torres Strait of each island having its own distinguishable stock of Hawksbills. My experience in the Pacific is somewhat opposite to that of Carr and Main; I found that the variation even in the Hawksbills in one area is so great as to mask regional differences. A possible explanation of the Torres Strait farmed turtle observations is that there were other variables in the stock examined than the island of origin; for example, if some of

if some of the holding tanks were relatively shaded, they would produce turtles with less shell pigment, and so on. Also, nature and abundance of food surely has a major effect upon the growth patterns of a Hawksbill shell.

Applying these thoughts to the Vieques situation, we have a case in which Hawksbill turtles are still found around the islands after many years of bombing activity. Clearly, if a bomb strikes very close to a turtle, the individual turtle is killed. Doubtless this has happened from time to time since the inception of bomb testing around Vieques, but it would be unlikely to be recorded and no cases have come to our attention, even anecedotally During the 1980-81 study, we found a disproportionate amount of nesting activity on beaches close to and on the range, so there is obviously not a total incompatibility between the naval bomb operations and turtle nesting. If beach selection is truly unconstrained by other considerations, one could even theorize that the chances of a turtle nesting successfully on range beaches are greater than on civilian parts of the island, the chance of a turtle or nest being destroyed by bombing activity being remote and theoretical and the chances of the turtle or its eggs, or both, being taken illegally for food on the civilian parts of the island much more real. More probably, however, the distribution of nesting activity observed today reflects ecological and structural conditions of the beaches and their associated marine habitat.

We have observed significant changes in the distribution of turtles spotted at-sea even in the course of three months aerial survey; they tended to concentrate around the range in August (a nesting month), and were scattered much more uniformly around the island in late October (after the main nesting season). This could be relatively easily explained as

turtles during the nesting season living in the general vicinity of the nesting beaches. However, the proportion of turtles seen that actually nested, even once, in 1981 is surely small, and in any case the great increase in absolute numbers of turtles spotted in October versus April remains, for the time being, unexplained.

It would be highly desirable for some level of ongoing aerial surveys of Vieques turtles to be maintained. While nesting distribution and intensity can now be considered relatively well-known, the changing seasonal distribution of turtles at sea is of the greatest interest and should be studied at least monthly by means of aerial survey.

9. RECOMMENDATIONS

The following recommendations are made to insure adequate levels of security and conservation for marine turtles in Vieques waters and on Vieques beaches:

i) Amphibious and landing maneuvers should, if possible, avoid Yellow, Purple and Turtle Beaches during the months of April to November. This period should be adequate to cover the time between the first nestings of the season, and the emergence of the last hatchlings.

ii) On all other beaches, spot checks should be made before landing maneuvers are undertaken, to insure that there are no fresh or visible nests in the area. Frequently, turtle nests are made near the ends of major beaches, and if landings are kept to the middle, there would be reduced conflict.

iii) The bright lights on Cerro Matias should be dimmed, shielded, or curtailed during the turtle nesting season (April-October).

iv) V cular traffic should be kept off Yellow Beach, and if possible, all beaches.

v) The L ach road along the edge of the beach on the south side of the bombing range should be moved further inland, to avoid severe erosional and beach damage problems.

vi) Experiments should be conducted, presumably not on Vieques but

somewhere where nests are more abundant, to determine the effects of the weight of adult cattle both on an incubating clutch of buried eggs and on a group of hatchlings nearing the surface shortly before emergence.

vii) Aerial surveys should be conducted throughout the year, on a fortnightly basis during the winter and weekly during the summer, for one year to document both turtle nests and turtles at sea. This will both confirm the regularity of the nesting patterns observed in 1980 and provide year- round coverage of turtles at sea, which was not possible during our survey.

viii) Efforts should be made to get the camp guards at both Camp Garcia and the Naval Ammunition Facility to inspect contents of the vehicles they check, with the intention of intercepting efforts to smuggle turtle eggs and turtle parts.

xi) If more detailed information is considered necessary about the turtles on and around Viques, a netting and tagging program is considered advisable and highly beneficial.

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